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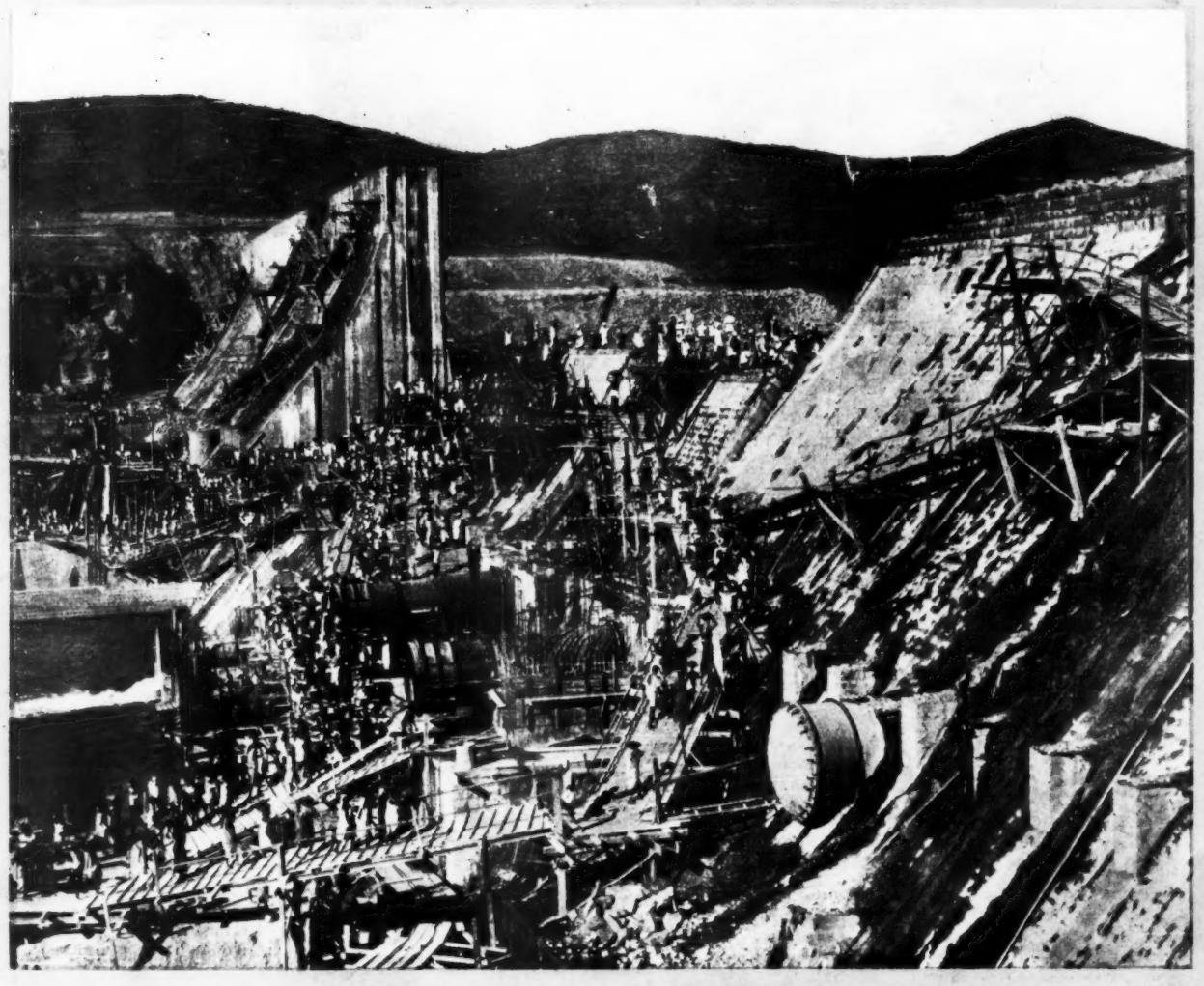

JALAPUT DAM UNDER CONSTRUCTION

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HEAVY DUTY
TRANSMISSION
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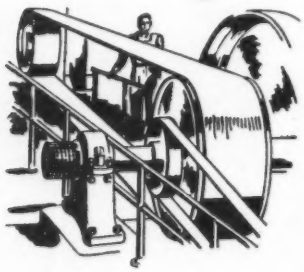

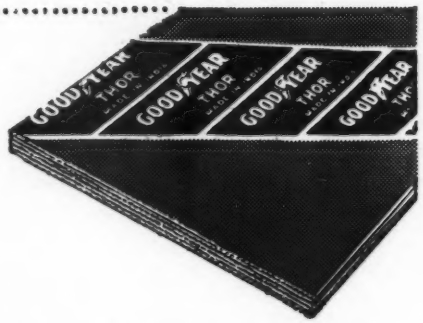

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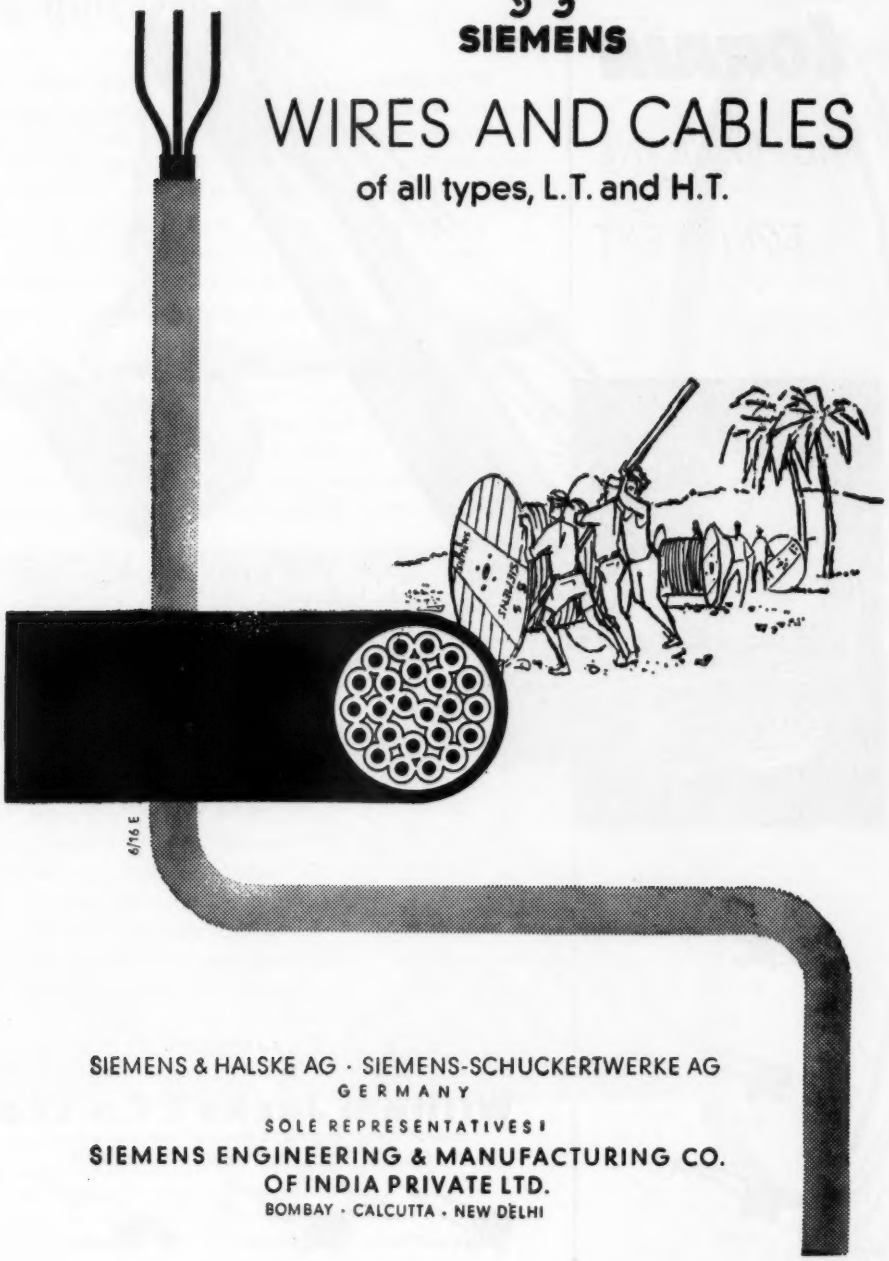

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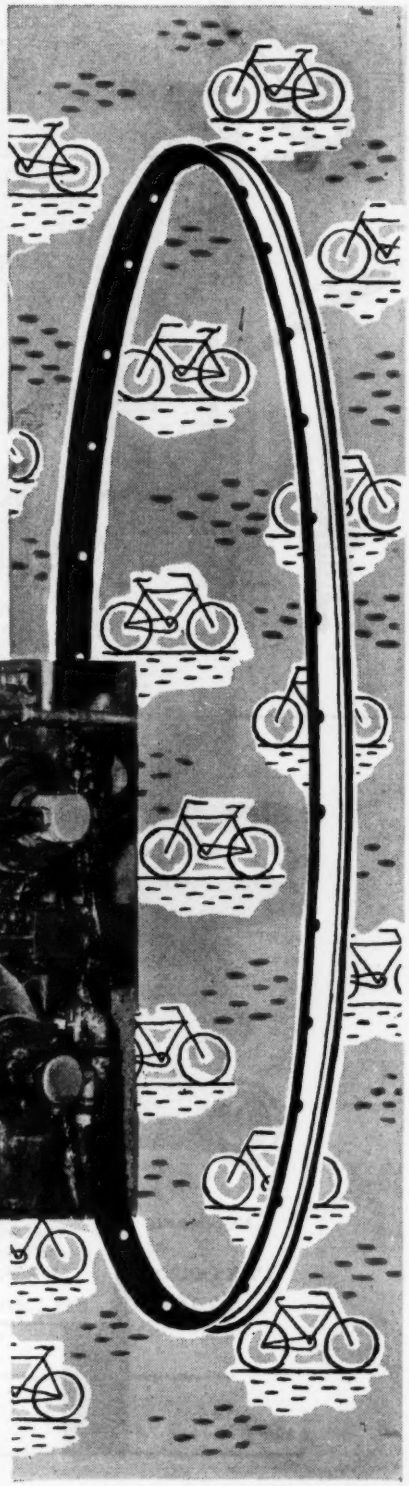

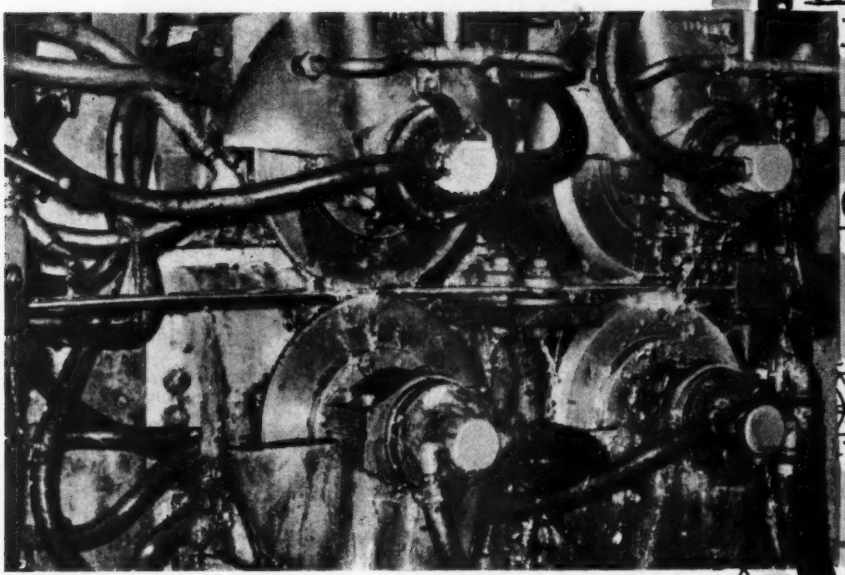

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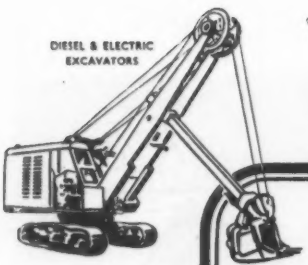
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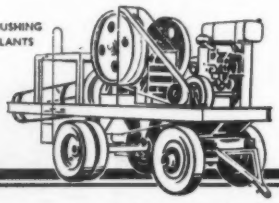
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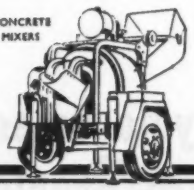
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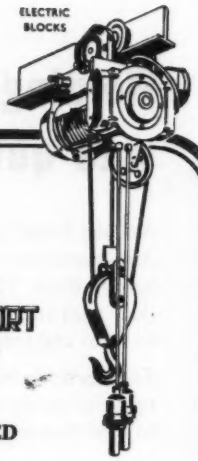
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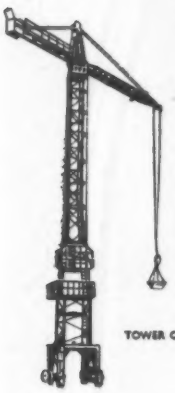
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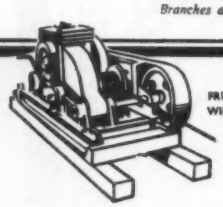
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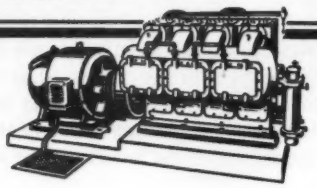
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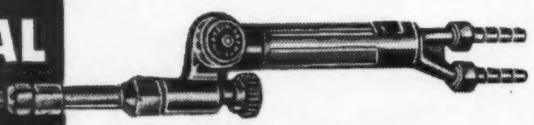

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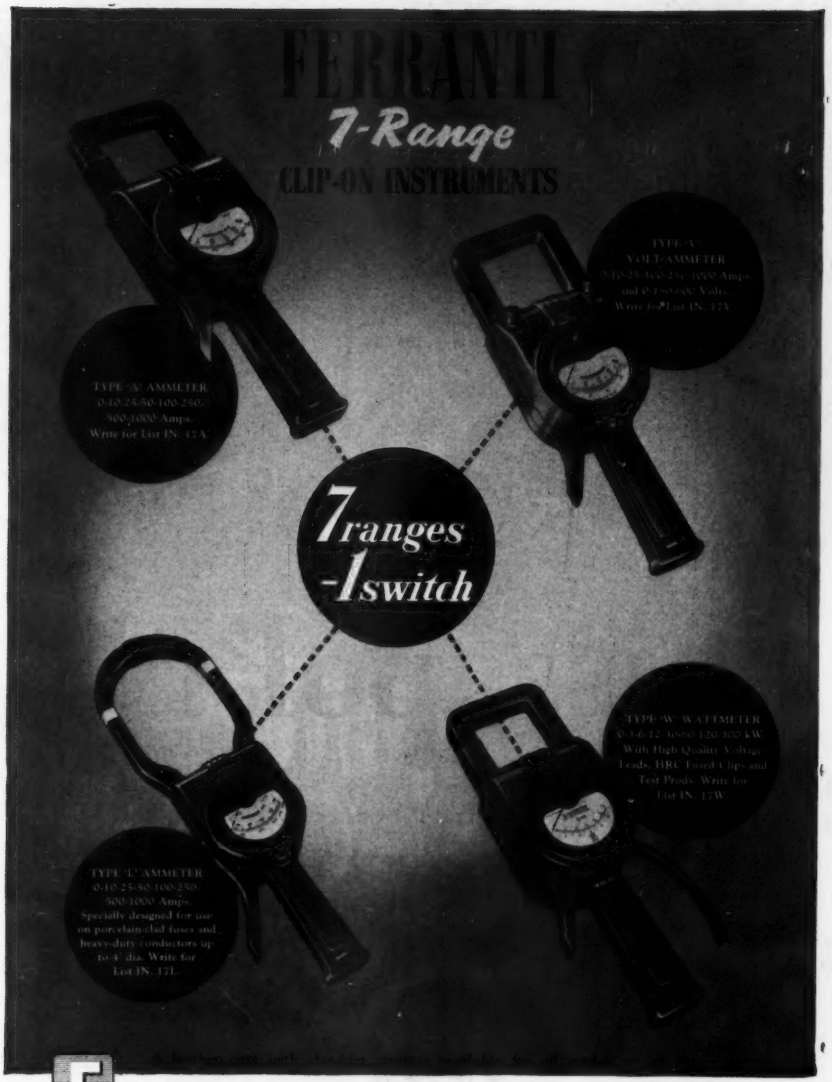

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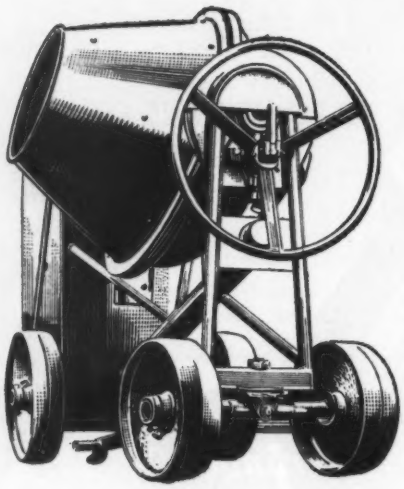

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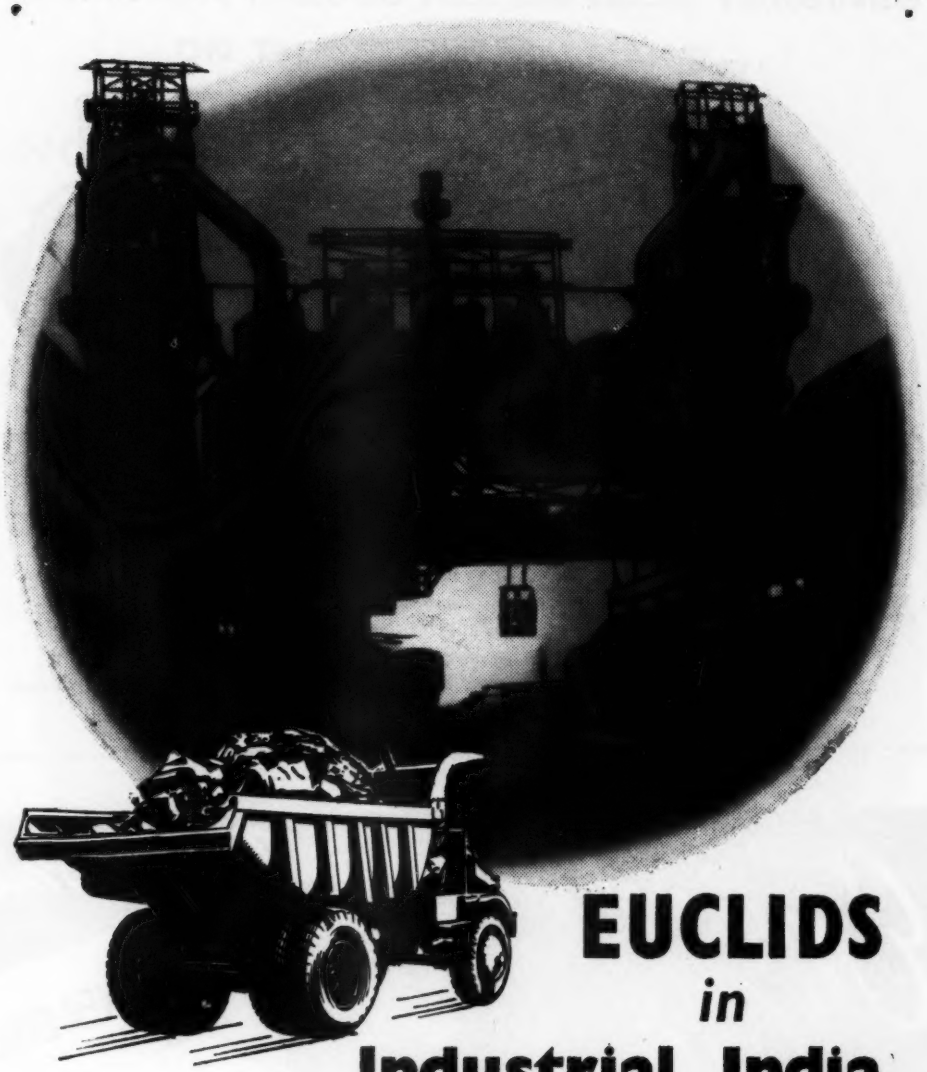

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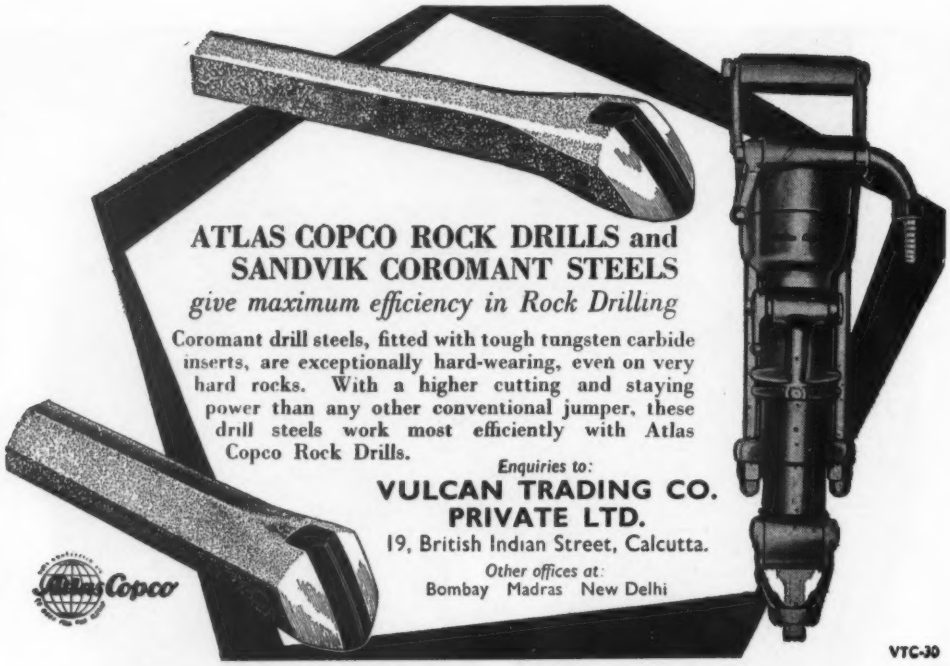

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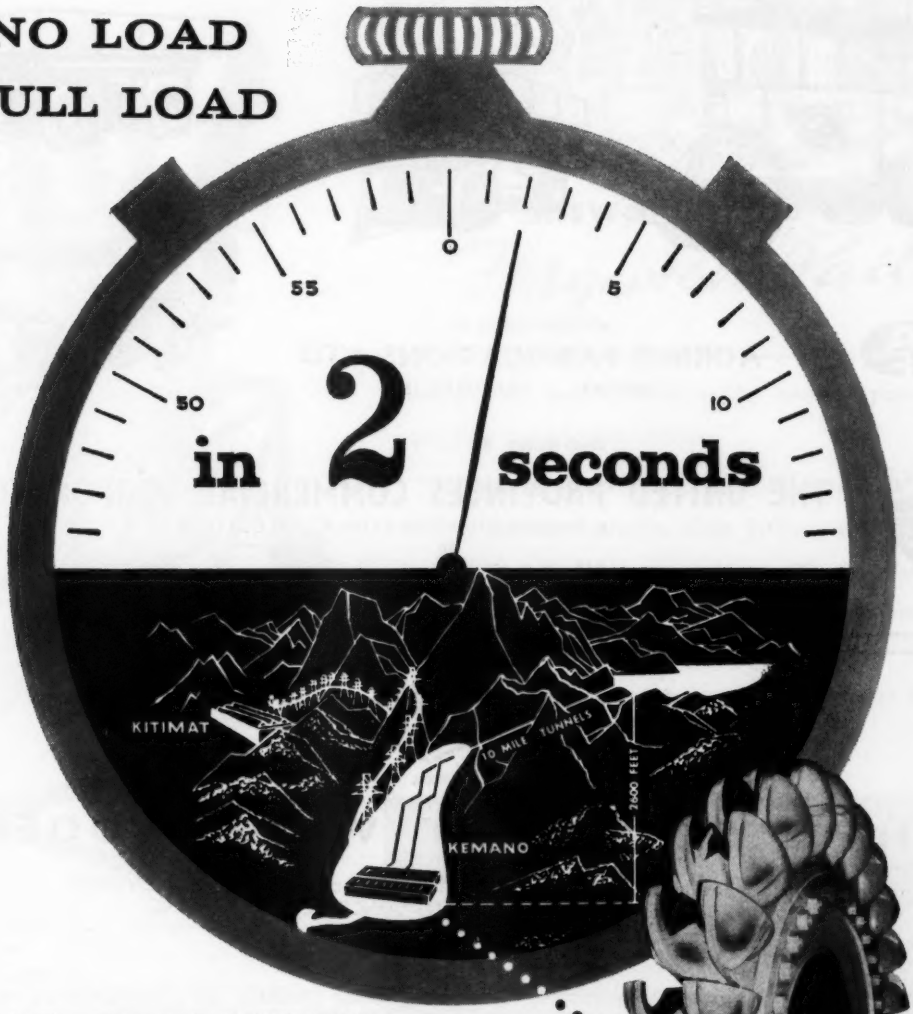

This spectacular performance is standard operation at Kemano. Dominion turbines provide this almost instantaneous supply of power, required by the pot lines at the Kitimat Smelter. Since July, 1954, when The Aluminum Company of Canada started producing aluminum at their Kemano-Kitimat development, Dominion turbines have established a record of proven reliability, with negligible down time, under an operating head of 2,500 feet.

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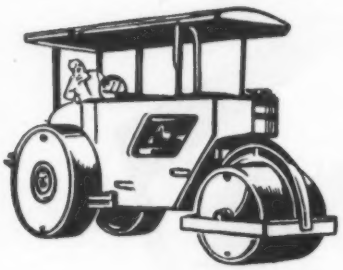

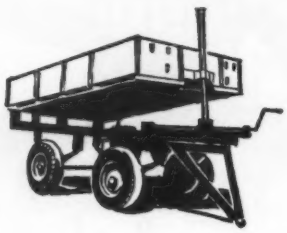

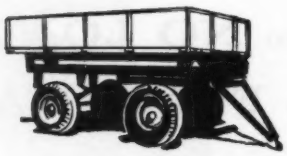

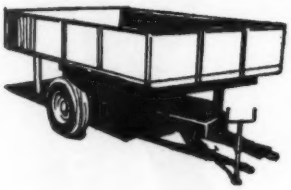

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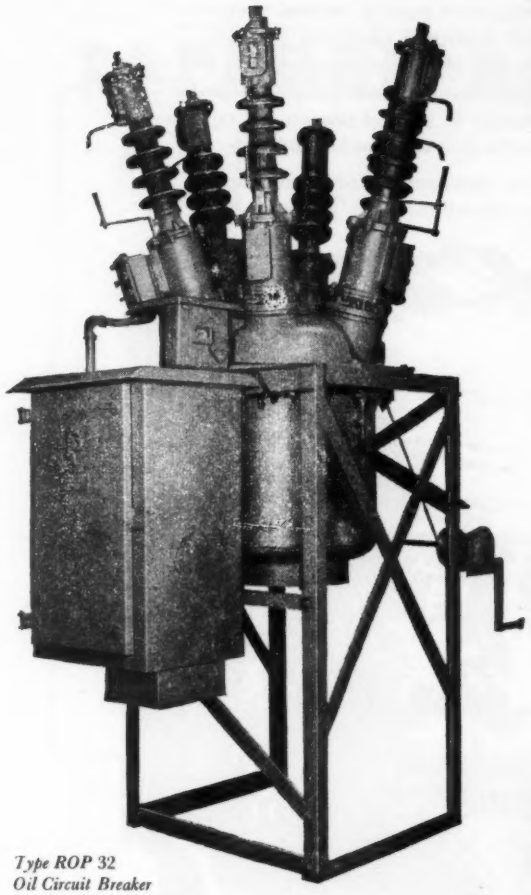

Type ROP 32
Oil Circuit Breaker

Two examples of 'Ferguson Pailin' switchgear, for varying duties, are illustrated here. They are :—

ROP 32 OIL CIRCUIT-BREAKER

Wherever 22 kV or 33 kV outdoor oil circuit-breakers for breaking capacities up to 750 MVA are required the merits of the 'ROP 32' breaker should be considered.

The design of this breaker provides for the optimum protection against adverse working conditions peculiar to countries in various parts of the world as well as maximum resistance to the effects of fluctuating temperatures and humidity.

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The circuit-breaker tank is of cylindrical shape and all three phases are brought into one tank, permitting the use of smaller framework thereby achieving compactness.

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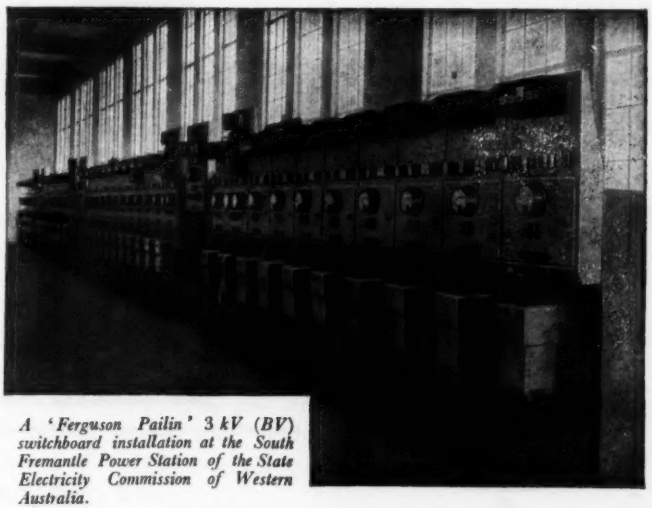
Vertical isolation of the breaker ensures minimum space requirements of the unit, whilst adequate interlocks safeguard against mal-operation.



A 'Ferguson Pailin' 3 kV (BV) switchboard installation at the South Fremantle Power Station of the State Electricity Commission of Western Australia.

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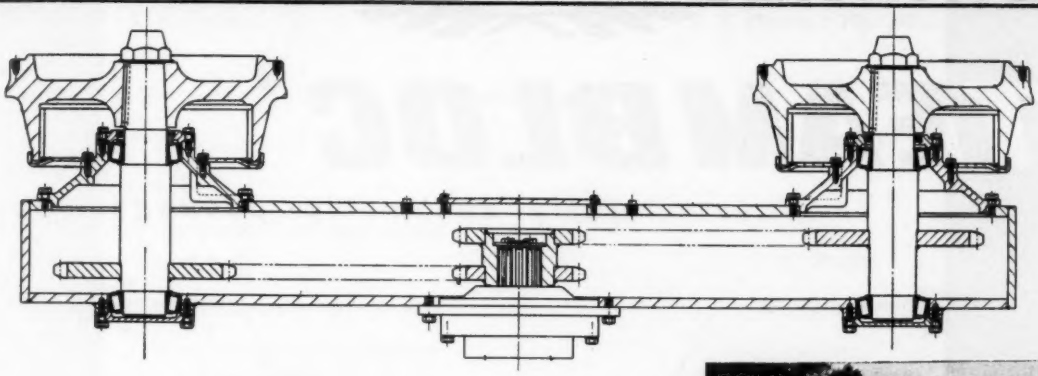
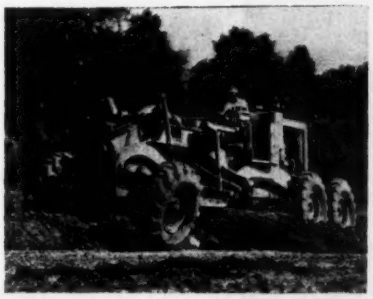


HOW THE GALION IRON WORKS AND MANUFACTURING CO. MOUNTS THE TANDEM REAR WHEELS OF THE WORLD'S BIGGEST GRADER ON TIMKEN MADE-IN-U.S.A. TAPERED ROLLER BEARINGS.



Timken bearings take giant loads on world's biggest motor grader

This 40,125 pound Galion Motor Grader moves tons of earth in one pass. To keep this giant working, engineers specified Timken made-in-U.S.A. tapered roller bearings at vital points.

Galion, like most construction equipment manufacturers, uses Timken bearings because they: 1) *Have greater capacity.* Full line contact between rollers and races gives Timken bearings extra load-carrying capacity, and the taper lets them take any combination of radial and thrust loads (as shown at right); 2) *Take shock.* Timken bearings, made of our own special analysis steel, are case-carburized to give them hard, wear-resistant surfaces and tough, shock-resistant cores; and 3) *Need less maintenance.* Timken bearings keep shafts concentric with housings—make closures more effective, keep dirt out, lubricant in.

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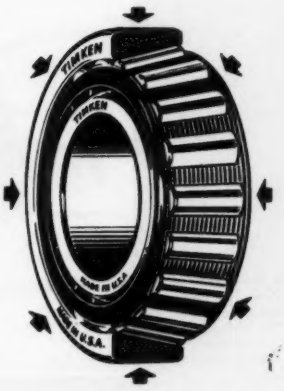

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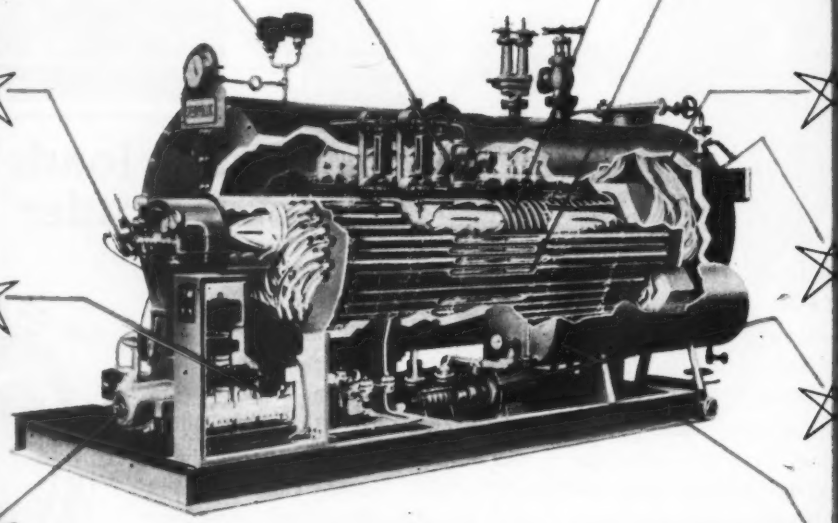

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : K. K. Sinha — P. K. Menon : Mg. Editor

VOL. VII — **DECEMBER 1957** — **NO. 12**

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Editorial and Managerial Offices
6/2, MADAN STREET, CALCUTTA-13. PHONE : 23-1765 & 23-5855. GRAM : TEKJOURN
Manager : B. Bhattacharya

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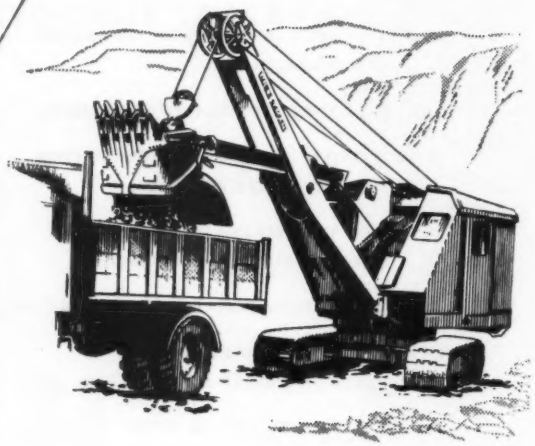

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On the Development and the Shapes of Surge-Tanks

By P. G. FRANKE

With the intensive completion of water-power-plants within the last decades, two problems which occupy the civil-engineer as well as the designer of water-power-machines have become of particular importance. They are shaping surge-tanks and the phenomena of water-hammer. Recently the two problems have intensified considerably, because one has given up the original construction of single plants in favour of the construction in groups or schemes. This form of completion is especially used for high-pressure-plants; generally in connection with making big reservoirs. Careful research of the above-mentioned questions is necessary if work in the plant is to run smoothly.

In the following expose some remarks will be made about the development and the shaping of surge-tanks and the calculation of level-movement in them.

General introduction

Normally a water-power-plant consists of the following principal parts :

Water-reservoir and intake
Headrace
Power-Station
Tailrace

The tailrace may possibly go into the river or into another reservoir.

The conditions in the power station vary according to the energy production and working methods used. The discharge sways between zero and the whole capacity, that is

$$0 \leqq Q_B \leqq Q_{1/1}$$

The flowing water is not able to meet atonce the comparatively quick changes in water requirements. These hindrances to having a permanent flow of water causes fluctuations which do not cease until the beginning of a new stationary condition.

In the case of derivations with free water-level these fluctuations appear as waves along the channel. These movements are normally not noticeable at run-of-river plants. With canal plants a compensating basin or a tank, if necessary with overflow, can be constructed to diminish the waves. If a penstock follows the open canal the tank is situated between them. These tanks are the first sorts of organs of regulations.[1]

For such plants variation of discharge is only possible within narrow limits. Canals or tunnels with free water-level can only be used if in the reservoir little difference of water level occurs between high water and low water.

In the case of water supplies under pressure a separate structure, called a surge-tank, is interposed for compensating the changes in discharge. These disturbances appear in the form of periodical oscillations of the water level in the surge-tank. Changes of water flow are rapidly possible by increasing pressures. In these plants ordinarily more or less high differences of water level in the reservoir are possible. This difference between high and low water levels in the reservoir is also important for the dimensions of the surge-tanks apart from the limited water level movements. For example, the water level difference at the Molveno-S. Massenza-scheme (Italy) is 100 m ; the surge-tank is about 175 m high [18].

If the discharge from the surge-tank is equal to the inflow, there are steady conditions. Each variation of capacity (e. g. from N_0 to N_1) causes a change of the flowing water (from Q_0 to Q_1) which disturbs the previous state of rest. The amplitudes of the oscillations caused by this are generally quickly reduced if the dimensions are favourable.

If the water swings up the surge-tank it must not be allowed to overflow; if it swings down there must be a sufficient quantity of water over the pressure line, so that air may not get into these pipes. If air does enter, knocks may result which eventually are dangerous for these parts of construction, in any case there may arise a great irregularity of work. Care must be taken that a surge-tank with roofing has sufficient ventilation.

Short pressure lines can be constructed without surge-tank. This is the case with water-power-plants directly under a reservoir or a storage basin.

(1) For example :—Vizzola on Ticino (1880-84), Italy [11] ; Töll on Etsch (1898), Austria, to-day Italy [8] ; Lend on Gasteiner Aache (1898), Austria [8].

The position of a surge-tank

With regard to the position of a surge-tank to the power station we distinguish two cases :

(A) The surge-tank is situated upstream.

(B) The surge-tank is situated downstream.

In this definition the direction of flow is considered (fig.1).

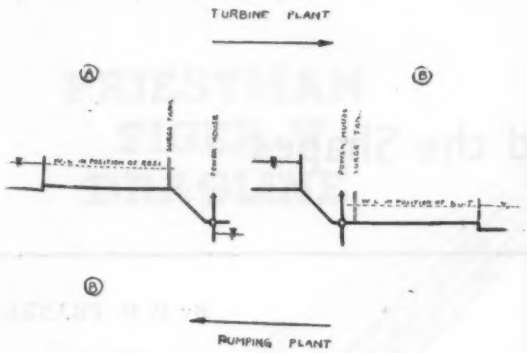


Fig. 1 : The position of a surge tank
(A) The surge tank is situated upstream
(B) The surge tank is situated downstream

The case that a surge-tank, according to the kind of work, may be situated upstream as well as downstream appears at pumped storage hydro-power plants [5]. In the power house are installed the turbines and the pumps.

In special cases the surge-tank may be admitted from both directions simultaneously. This takes place during the diminution of the load of a pump when the closing mechanism fails and the pump turns back under the hydrostatic pressure from the high storage basin. Therefore it is necessary to calculate the amplitudes for this undesirable case too [5].

Natuarally the construction of a surge-tank upstream as well as downstream may be necessary.[2] Further it is possible to interpose in a water-derivation two or more surge-tanks[3] and in analogy to direct in or away from a surge-tank, two or more lines.[4]

The surge-tank is situated upstream

This position is the most frequent of all (fig.2). The part between the inlet and the surge-tank mostly has a relatively little slope and is constructed as a gallery. In the reach of main head there is a pressure pipe.

The greatest amplitude above water level in position of rest comes at a quick change-over from whole capacity to complete load rejection, that is

$$N_o = N_{1/1} \quad \text{and} \quad N_1 = 0$$
$$\text{or} \quad Q_o = Q_{1/1} \quad \text{and} \quad Q_1 = 0.$$

The absolutely highest water level in the surge-tank is in this case reached if in the reservoir there is the highest water level, in other words, if there exists the highest water level in position of rest.

Normally in big modern turbine-plants there are only partial diminutions of load. Further the turbines in idle-run also need some water. But with regard to eventual accidents the complete and almost sudden turning off of the greatest operating quantity of water is taken into consideration.

The greatest amplitude below the water level in position of rest appears at a sudden change-over from starting up the machines to whole capacity, that is

$$N_o = 0 \quad \text{and} \quad N_1 = N_{1/1}$$
$$\text{or} \quad Q_o = 0 \quad \text{and} \quad Q_1 = Q_{1/1}$$

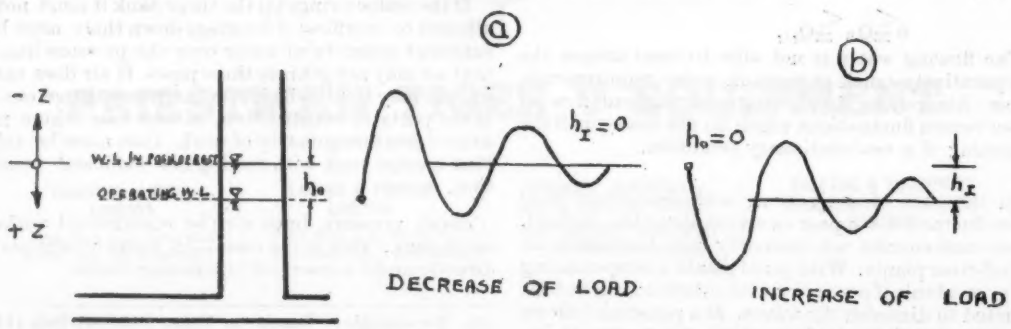
The absolutely deepest water level in the surge-tank is reached in this case if in the reservoir exists the lowest water level.

In big turbine-plants there appear only partial increases of load. Specially they depend on the kind of work and the number of machine-groups in the plant. For example, it is mentioned by F. Vogt [23] that one takes as basis with a momentary increase of 30 % at Porjus power plant (Sweden) and with an excess of 15% at Nore power plant (Norway).

Generally sudden and extreme increases of load are possible because the excess pressure, arising between the intake and the surge-tank, promptly accelerates the water in the pressure line. Naturally the quantity of water which can be discharged from the surge-tank is decisive.

The situation where there is a sudden decrease in load and a sudden increase in load results in each case in rather excessive values in the amplitudes because

Fig. 2 : The surge tank is situated upstream
(a) Change-over from work to rest of work
(b) Change-over from rest of work to work



(2) E.g. Porjus-plant, Sweden [23] (3) E.g. Piave-Boite-Maé-Vajont-scheme, Italy [1] (4) E.g. Partidor-plant, Italy [7]

the shutting and the opening of a water-power machine cannot be done suddenly. Given the right prerequesites there is some more security in this situation.

The surge-tank is situated downstream

The explanations of the upstream surge-tank are analogous here. The first amplitudes over the water level in position of rest appear at increase in load, and those below them at decrease in load.

Special features

On principle it may be said that the amplitudes at rise of load can be held within desirable limits by gradually increasing the load. But a large decrease of load cannot be prevented. Therefore at all events the second amplitude at the greatest possible decrease of load must be calculated, because it may be greater than the first highest swing appearing during the increase of load while the machine is working.

The working methods must ensure that an unfavourable addition of swings is to be prevented. Therefore it is expedient to install a water level indicator in the power-house. The individual manoeuvres of work especially in large plants, must be carefully synchronized.

The particular water levels upstream and downstream are different with regard to the method of working and the amount of water. The most unfavourable conditions for each kind of work must be found separately, because the equivalent quantity of water depends on the particular fall-head as well as the amplitudes in a surge-tank are related to the respective water level in position of rest. The amount of operating water as a function of the fall-head may be determined :

$$Q = Q_{1/1} \sqrt{\frac{H}{H_{1/1}}}$$

The amounts of water accorded to two different fall-heights, are in relation to the root values of these absolute fall-heights. The values of full capacities are designated by the index 1/1.

The water level in position of rest is the level of that reservoir which is situated behined the surge-tank as seen from the power station (fig. 1).

The water-quantity Q

The amount of water flowing through the surge-tank or discharged from it in the unit of time consists of the operating water Q_B and the possible non-operating water Q_E. That is

$$Q = Q_B + Q_E$$

The operating water Q_B corresponds to the particular quantity of turbine water Q_T or the pumping water Q_P. With regard to the direction of flow in each steady condition the following signs are to be noted (fig. 3) :

Flow from the surge-tank to the power station $= +Q_B$.

Flow from the power station to the surge tank $= -Q_B$.

For plants with the surge-tank arranged upstream, the positive sign is authoritative and for those arranged downstream, the negative sign.

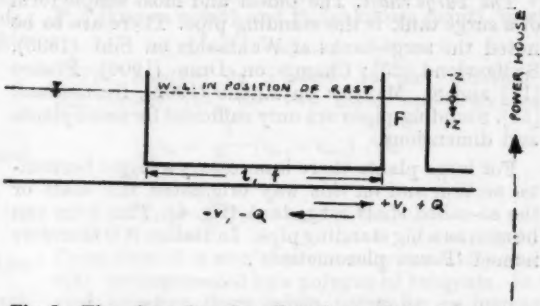


Fig. 3 : The signs for the directions of flow and the amplitudes of water level.

Generally the capacity of operating water for a present fixed situation shall be noted with Q_o and that for the following situation with Q_1. Corresponding to the kind of load we get for the difference $\triangle Q = Q_1 - Q_o$ at surge-tanks which are loaded from one direction only the following values :

Surge-tank situated upstream

$\triangle Q < 0$ for decrease
$\triangle Q > 0$ for increase

Surge-tank situated downstream

$\triangle Q > 0$ for decrease
$\triangle Q < 0$ for increase

The sign of $\triangle Q$ is equal to that of the first amplitude. Therefore it shows the direction of the initial movement of the water level in the surge-tank.

The transition from Q_o to Q_1 may be gradual and in special cases nearly sudden too. During a gradual transition there is $Q_B = Q(t)$. In case of a sudden change there is $Q_B = Q_1$.

Q_E denotes the sum of non-operating water which is discharged from the surge-tank in the unit of time. In each case there is $Q_E = Q(t)$.

Conditions of roughness

The conditions of roughness in the gallery have an important influence on the complete course of swings. For example, if the surge-tank is situated upstream the water swinging up will become greater when the resistance of the gallery is smaller and the water waves swinging down will be greater when there is stiffer resistance. If on the other hand the surge-tank is situated downstream the conditions there are reversed, that means the greatest amplitudes in an upward direction appear when there is stiff resistance in the gallery and those downwards when there is little resistance.

For the correct representation of the conditions it is necessary to calculate *each* case of work with the highest and the lowest value of roughness which are possible. The swings which may appear during the work may then lie between those limits. The best possible determination of the coefficient of resistance $\lambda = \lambda(R_e ; r_s)$ as a function of the Reynolds number and the relative roughness can be given with the formulae of Colebrook and Supino [2, 21, 4].

The shapes of surge-tanks

The different forms of surge-tanks which are connected to water derivations under pressure can be divided into three general types.

The surge shaft. The oldest and most simple form of a surge tank is the standing pipe. There are to be noted the surge-tanks at Waldhalde on Sihl (1895), Switzerland [25]; Champ on Drac (1900), France [11] and St. Maurice on Rhône (1902), Switzerland [11]. Standing pipes are only sufficient for small plants and dimensions.

For large plants there is necessary a bigger horizontal section and on this way originated the shaft or the so-called shaft surge-tank (fig. 4). This form can be seen as a big standing pipe. In Italian it is therefore named 'Pozzo piezometrico'.

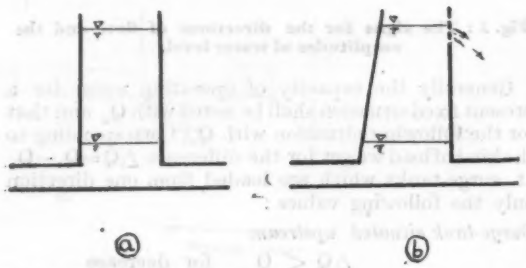


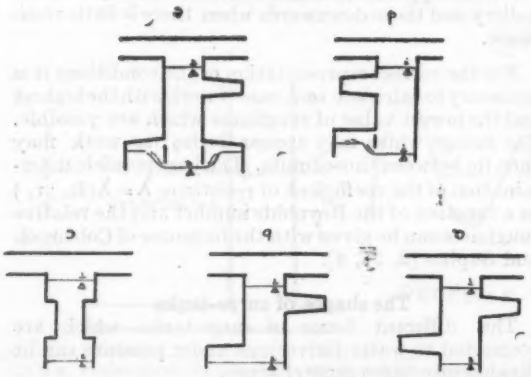
Fig. 4 : The shaft surge tank
(a) With constant cross section
(b) With variable cross section and spillway

Upswings may be damped by planning a spillway. To prevent an unnecessary loss of working water the crest of the overflow must be situated over the highest water level in position of rest. An increase in the quantity of water which can be drawn off at increase of load is only possible by an enlargement of the section in the deeper parts of the surge-tank.

It is evident that in the same conditions the amplitudes will become smaller if the section of the surge-tank or the proportion of sections $\Phi = \frac{F}{f}$ becomes larger. This development naturally has limits.

The chamber surge-tank. The amplitudes can be reduced by rooms on side of the shaft which enlarge the volume (fig. 5). In this case the shaft can have a minimum section. So the water level reaches quickly the limits of the swings and a fast variation of the pressure conditions is given. At plants with high differences of the water level in the reservoir the excavation of rock is reduced also. This kind of a surge-tank has been planned first at the Lōntschwerk (1905) in Switzerland [19].

Fig. 5 : The chamber surge tank
(a & b) With two chambers
(c) Type of the Ritom-plant
(d & e) With spillway in the upper chamber



An overfall at the entrance in the upper surge chamber causes an additional enlargement of the pressure conditions in the shaft. This effects a more fast retardation of flow in the gallery and therefore the volume of the upper chamber can be lesser. For this kind the spare-surge-tank (Sparwasserschloss) has been granted a patent in Austria [19]. For the discharge of water into the shaft there are particular openings. For the dimension of such dischargeopenings, the time of outflow is important which must be in a certain ratio to the time of swinging.

Ofcourse the shaft may be constructed in slope also and as safety-device an over-fall can be arranged which directly comes out, like in the above mentioned Lōntschwerk.

The variant instead of chambers on the side to expand the cross section of the upright shaft (Ritom-plant in Switzerland) has not been advantageous [19].

The surge-tank with throttled inlet. By diminishing the section of the inlet into the surge-tank (fig. 6) there occurs an essential damping of the amplitudes. This, however, claims with a particular intensity in the gallery. At upswings arises an additional pressure and at downswings a reduction of pressure. Further, this kind of surge-tank is very sensitive to sudden impacts.

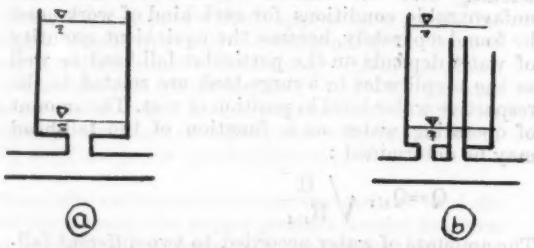


Fig. 6 : The surge tank with the restricted orifice
(a) Simple throttling of the inlet
(b) Differential surge tank by Johnson

In the case of constructing of chicaneries it is uncertain to assume precisely the coefficients of resistance. Therefore model tests will be necessary or the calculation may be done with exact empirical factors. To these particular difficulties there are references e. g. by Vogt [23], Streck [19], Ludin [13], Frank-Schüller [3] and Jaeger [9].

If the coefficients of resistance for the thrushing will be guessed, the calculation may be correct formally, the results, however, may be nearly tallying with the nature. The utility of any marginal values does not serve any practical purpose, because for the conditions of roughness in the gallery there must yet be taken two acceptances and so the difference of these amplitudes will be too high.

The possibility to fix a metal plate at the entrance by which the opening can be regulated later, also is not satisfactory. In this case the question must be considered: What can or what must happen, before in the later time of work a regulation will be done ?

A special form of this kind of surge-tank is the type constructed by R. Johnson [10], called the differential-surge-tank.

The additional arrangement of chambers, spillways and several resistance-structures, naturally is possible. If the resistance-constructions are in different heights the sensibility against sudden impacts is reduced.

The main-equations for the calculation of level movements

The first equation for the movement of water-level follows from the condition of continuity.

$$dz = \frac{f}{F}\ (c - v)\ dt. \qquad (1)$$

There is $c = \frac{Q}{f}$ an assumed velocity which would be existing if the discharge from the surge-tank in unit of time (operating water and non-operating water) would only be flowing through the gallery.

The second equation follows from the fundamental equation of dynamics.

$$dv = \frac{g}{l}\ (z - h)\ dt. \qquad (2)$$

In this, h is the pressure head which is necessary to produce the velocity of flow v and to overcome the resistances in the gallery. It is considered analogeous to the amplitude z, over the water-level at rest as negative and below them as positive (fig. 3). For the calculation, the following equation is used[5]

$$h = \frac{1}{2g}\left(1 + \lambda\frac{l}{4R} + \Sigma\zeta\right) v^2 = \xi v^2$$

It must be noted that h is always to be affixed with the same sign as the mean velocity of flow v. The factor ξ is the coefficient of pressure head. Every water-power plant has its own constant value of ξ.

By eliminating v from the above equations (1) and (2) the differential equation of the second order between z and t will be obtained. Further by eliminating z the relation between v and t follows. Dividing equation (1) by equation (2) or vice versa relations between z and v will be arrived at.

In these equations generally the values l, f and g are constant. The integration is impossible. Even if Q = const. and F = const., it is not possible too. Only in the particular case at sudden transition from a position of work to full stop an integration is accomplied once. For this case Ph. Forchheimer [6] has given by referring the work of F. Prasil [14] the equations for the determination of the maximum amplitudes. Other solutions have been published some years later. They can be easily transformed to the simple formula of Forchheimer.

The step by step calculation of the course of swinging

The course of the water level movement in surge tanks can be only calculated by a step by step method. This method of calculation is always practicable. It is suitable to make the computation tabulated.

In the following considerations the values of the interval, that are to be calculated are affixed with the index (n). This interval lies between the point P_{n-1} (known point) and P_n (unknown point), in short

$$\triangle x_n = x_n - x_{n-1}\ .$$

The solution by Pressel. In the solution by K. Pressel [15] the two main equations are as

$$\triangle z_n = \frac{f}{F_{n-1}}(c_{n-1} - v_{n-1})\ \triangle t_n$$

$$\triangle v_n = \frac{g}{l}(z_{n-1} - h_{n-1})\ \triangle t_n$$

From these it is seen that the curves z=z(t) and v=v(t) are superseded by a polygon of tangents. In this case however, there exists naturally an increase of difference between the actual course of the concerned curve (fig. 7). In the year 1920 D. Thoma [22] had already pointed out that this method, also for small intervals of time, will suffice only for the apporximate determination of the first amplitude.

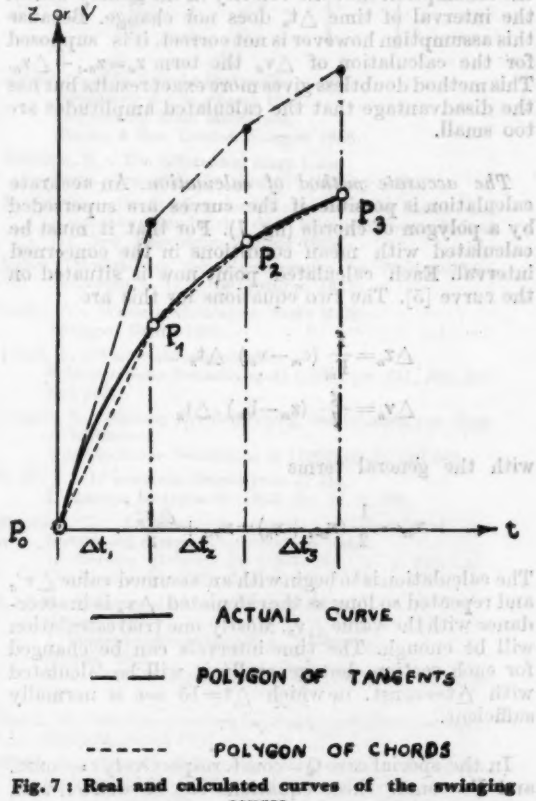


Fig. 7 : Real and calculated curves of the swinging course

The amplitudes which result from this method are always larger than the real values. Therefore the total time of swinging is considerably greater although the periods are reproduced nearly exact. In comparing calculation for two plants with Φ=6,3 and Φ=9,9 under very different working conditions there was found the following percentage difference of the maximum amplitudes from the exact values :

1st amplitude	approximately	25 %
2nd amplitude	„	80 %
3rd amplitude	„	150 %

(5) R = Hydraulic radius ; in the case of circular cross section follows 4R = d .
$\Sigma\zeta$ = Sum of the coefficients for the additional loss-heads between reservoir and surge tank.

In the example for calculation given from Pressel [15] with Φ=50,0 there results a difference of 3,5 % for the first amplitude and in an used example by O. Streck [20] with Φ= 33,1 as such of 13,5 %. In new plants of today the ratio of sections however is almost under the value of Φ=20 which Pressel, about 50 years ago, has called "very small".

An improved method of calculation. Another determination of the intervals, which is used, for example, by Leiner [12] and Streck [20] follows from the equations :

$$\triangle z_n = \frac{f}{F_{n-1}} (v_{n-1} - v_{n-1}) \triangle t_n$$

$$\triangle v_n = \frac{g}{l} (z_n - h_{n-1}) \triangle t_n$$

The value $\triangle z_n$ is calculated as Pressel's method under the assumption that the velocity in the gallery within the interval of time $\triangle t_n$ does not change. Because this assumption however is not correct, it is supposed for the calculation of $\triangle v_n$ the term $z_n = z_{n-1} + \triangle z_n$. This method doubtless gives more exact results but has the disadvantage that the calculated amplitudes are too small.

The accurate method of calculation. An accurate calculation is possible if the curves are superseded by a polygon of chords (fig. 7). For that it must be calculated with mean conditions in the concerned interval. Each calculated point now is situated on the curve [5]. The two equations for this are

$$\triangle z_n = \frac{f}{F_m} (v_m - v_m) \triangle t_n$$

$$\triangle v_n = \frac{g}{l} (z_m - h_m) \triangle t_n$$

with the general terms

$$x_m = \frac{1}{2} (x_{n-1} + x_n) = x_{n-1} + \frac{\triangle x_n}{2} .$$

The calculation is to begin with an assumed value $\triangle v'_n$ and repeated so long as the calculated $\triangle v_n$ is in accordance with the value $\triangle v_n$. Mostly one trial calculation will be enough. The time-intervals can be changed for each section, but generally it will be calculated with $\triangle t$=const. in which $\triangle t$=15 sec is normally sufficient.

In the special case Q=const. respectively c=const. and F=const. these equations can be written with respect to $\triangle t$=const. in the simple form as

$$\triangle z_n = \frac{Q}{F} \triangle t - \frac{f}{F} \triangle t \; v_m = A - B \, v_m$$

$$\triangle v_n = \frac{g}{l} \triangle t \; (z_m - h_m) = C \, (z_m - h_m = C z_m - D v_m^2$$

The constants A, B, C and D will be computed before the general calculation (refer table). Here is to note that the constant D corresponding to the value h, has ever the same sign as the mean velocity of flow v_m. A further contribution is also given by H. Wegmann [24].

Approximate determination of the maximum amplitudes for different working methods of a plant

If the amplitudes will be computed from the new operating water level in the surge-tank instead of the water level at rest there follows : $y = z - h_I$. Here h_I is the difference in height of water level between the position of rest and the new operating level (fig. 8). In analogy there results for the maximum amplitudes (z_{max} =Z and y_{max}=Y) follows :

$$Y = Z - h_I$$

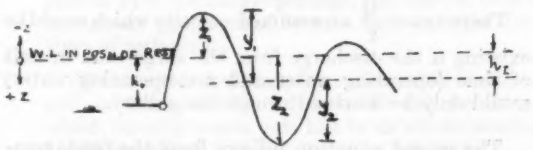
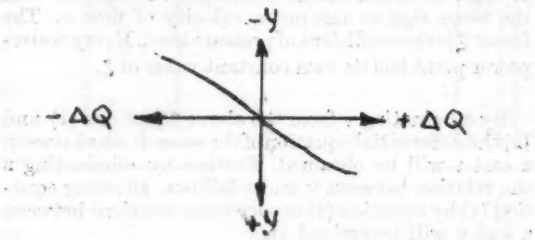


Fig. 8 : The maximum amplitudes computed from the water level of rest and that from the new operating water level.

If the calculated values for different kinds of working in a plant are drawn down as a function from $\triangle Q = Q_I - Q_o$ this graph can be used to find approximately all maximum amplitudes which will arise in each case at an intended change of work (fig. 9). For the calculation with ξ_{max} and ξ_{min} exists always a singular Y-curve.

Fig. 9 : The maximum amplitudes computed from the new operating water level as a function of $\triangle Q$



Known are the terms of the consisting kind of work (Index O), the capacity of operating water, the velocity of flow in the gallery and the pressure-height of the new following operating water level which is to bring about (Index I). The value of Y can be seen in the graph of the curve and after them the maximum amplitude $Z = Y + h_I$ may be found out. So it is possible to get quickly a view over the maximum amplitudes of the kinds of work. This specially may be advantageous for plants with several possibilities for manoeuvres of work [5].

Conclusions

With the intensive use of water power, as has been mentioned in the beginning, and the construction of particularly very big plants, the surge-tanks get note-worthy load also and therefore they must have appropriate dimensions. As a characteristic factor can be seen the quantity of kinetic energy which must be changed in the surge tank. These values have arisen from about 10^2 tm to about 10^5 tm. Here are some examples :

Sihl-Werk [25]	120 tm
Leizach-Werk [19]	3500 tm
Walchensee-Werk [19]	12200 tm
Molveno-Massenza [18]	66500 tm
Ala / Etsch [16]	285000 tm

TABLE FOR CALCULATION

1		2			3			4			5			Rem.
Δt		$A=\frac{2}{F}\Delta t$			$B=\frac{g}{F}\Delta t$			$C=\frac{g}{l}\Delta t$			$D=\frac{g}{l}\varepsilon\Delta t$			
sec.		m			sec.			1/sec.			sec/m			
6	7	8	9	10	11=8+10	12=11·11	13=3·11	14=2·13	15	16=7+15	17=4·16	18=5·12	19=17·18	
t	z	v	Assumption $\Delta v'$	$\frac{\Delta v}{2}$	v_m	v_m^2	$B\,v_m$	Δz	$\frac{\Delta z}{2}$	z_m	$C\,z_m$	$\pm D v_m$	Δv	
m/sec.	m	m/sec.	m/sec.	m/sec.	m/sec.	m²/sec²	m	m	m	m	m/sec.	m/sec.	m/sec.	

With this enlargement naturally must make pace the shaping and the methods of calculation. In this exposé are remarked only the problems from the technical point of view, because at first a good and incontestable technical solution must be demanded. It is naturally, seen for long time, the most economic solution also.

During the treatment of this aspect there arose new problems as in other fields also, because each plant gives new questions.

The director of the Società Adriatica di Elettricità (SADE) at Venice, Dott. Ing. Dr.-Ing.h.c. C.Semenza [17] once said, that the ratio of knowledge and ignorance is constant because with the numerator enlarges the denominator also and therefore we have to recognize with modesty that there will be every very much to study.

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Ramagundem Thermal Power Scheme

By S. A. QUADER

The scheme envisages the construction of a thermal power station of 37,500 k. W. capacity at Ramagundem on the Grand Trunk route between Kazipet and Balarshah. The site for the power station is located in the heart of the rich coal producing area and supply of coal to the Power Station is from the Bellampalli Collieries which is about 20 miles from the power station. There are also possibilities of opening a coal field at Ramagundem. The power plant comprises of 3 alternators of 12,500 kW. capacity each, together with 6 boilers of 50,000 lbs per hour evaporation capacity each at 425 lbs per square inch pressure, turbines and associated equipment. The various civil works like colony quarters, roads, power house, workshop building, cooling tower etc., are complete. Erection of all 6 boilers as well as 3 turbo-alternators is over. The power generated at Ramagundem will be used for the following purposes :

1. To supplement the power supply at Hyderabad to meet the ever increasing demand for power in the metropolis.

2. For the supply of power to the districts of Karimnagar, Warangal, Nalgonda and Medak in Telengana region of Andhra Pradesh.

The transmission and distribution lines consist of :

(a) one 120 mile double circuit 66 kV line running from Ramagundem to Hyderabad, supplying power on the way to Peddapalli, Karimnagar and Siddipet

(b) One double circuit 66 k.V. line from Ramagundem to Sirpur to cater for the heavy industrial load coming up at Mancherial, Bellampalli and Sirpur.

(c) One 66 k. V. single circuit line from Ramagundem to Hanamkonda.

General view of the Power House

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(d) A number of 33 k.V. lines for supply into rural areas with subsidiary 11,000/440 V lines. At present 22 major towns and villages, increasing ultimately to 40, will be electrified and power supplied to lift irrigation sets along the route.

The communication between the power station and the various sub-stations will be by means of carrier system.

A noteworthy feature of the scheme is that all the transmission towers required for the project were designed, fabricated and erected by the departmental staff.

The total estimated cost of the original scheme is Rs. 406 lacs. The amount is revised to Rs. 500. 12 lacs.

Under the second Five Year Plan, it is proposed to increase the steam generating capacity of the station by the addition of one more boiler of 160,000 lbs per hour capacity and a cooling tower. A sum of Rs. 38.20 lacs has been provided for the scheme in the second Five Year Plan.

In order to cater to the needs of the large industrial concerns coming up in the region (Sirpur) it is proposed to erect a 66 k.V. double circuit line from Ramagundem to Sirpur. For this scheme a sum of Rs. 19.20 lacs has been provided in the second Five Year Plan.

The progress of work so far on the project is as follows :

The entire power house consisting of the 3 alternators, 6 boilers and their auxiliaries, circulating water pumps and cooling tower etc., were completed together with the main pumping station at river Godavari. The tests on all the boilers and alternators and 11 k.V. switchgear were carried out successfully. The power house has been commissioned in the month of June 1957 and power is being supplied now to the towns of Peddapalli, Sultanbad, and Mancherial.

The entire civil work such as colony roads etc., were also completed.

On the northern feeder the 66 k.V, double circuit transmission line from Ramagundem to Bellampalli which also includes the crossing of the river Godavari is completed.

The industrial concerns at Sirpur have come up for electricity supply for their factories demanding about 17000 kW of power. The estimate for the northern feeder has therefore been revised and government sanction obtained. The 66 k.V. single circuit transmission line from Peddapalle to Hanamkonda is in progress.

66 k.V. Line normal suspension tower

Allocation of Costs— Multi-Purpose River Valley Projects

By C. S. PARTHASARATHY

A multi-purpose river valley project is a scheme thrown across a river or in its valley or basin for exploitation, control and regulation of its water resources for purposes of irrigation, power, flood control, drainage, domestic, municipal or industrial water supply, navigation, etc. As is well known, there are under construction a number of such multi-purpose river valley projects in India like the Bhakra-Nangal in the Punjab and Rajasthan, the Damodar Valley Projects in Bihar and West Bengal, the Hirakud in Orissa, the Kosi in Bihar, the Chambal in Madhya Pradesh and Rajasthan. The various project features or facilities are designed to serve these different purposes or objectives, either singly or jointly.

Why Cost Allocations

Funds are appropriated by Government agencies for construction of these projects and it is found necessary to apportion or allocate costs of multi-purpose project features such as storage dams, power-cum-irrigation or irrigation-cum-navigation canal system among the various purposes to be served by that structure. This process of apportioning to such purpose in a multi-purpose river valley project, an equitable share of the total or aggregate cost of the project is termed 'Cost Allocation'. The need for this process is occasioned by the utilisation of a project to render services of varied nature and by requirements of Government orders or statutory law as in the case of D.V.C. This forms the basis for working out financial forecasts and for determining its financial soundness or feasibility, for determination of repayment obligation on the part of State Governments who borrow long-term, interest-bearing loans from the Centre for financing these projects, for fixing the rates or charges to produce the necessary revenues from power, irrigation water supply etc. It is usually necessary in the economic analysis of projects when public policy which should decide whether project costs shall be financed by general taxation, by assessment of charges from the beneficiaries or by other means, requires that charges for all or certain products or services of the project shall be based upon the costs incurred therefore. It is for these reasons that cost allocations to the various project purposes must be made. Incidently, it may be mentioned, in this context, that the funds for multi-purpose river valley projects appropriated in U.S.A. fall into three general categories :

(*i*) Non-Reimbursible	Navigation, Flood-control, Fish and Wild Life (non-reimbursible).
(*ii*) Reimbursible without interest	Irrigation and Fish and Wild Life (reimbursible)
(*iii*) Reimbursible with interest	Commercial Power and Municipal and industrial water services.

It will be observed that the cost allocated to Flood Control and Navigation are non-reimbursible. The cost allocation to each of these three categories must be determined by the assignment of specific costs (i. e. readily indentified with a single function) and apportionment of joint costs (i. e. related to two or more functions) which terms are explained in the immediately succeeding paragraphs. The principal theme of this paper will be the distribution or allocation of the joint costs of project facilities or features.

Basic Concepts

Project costs may be broadly divided into three, namely, Specific costs, Separable costs and Joint costs. These are defined and described as under :

(*i*) *Specific costs* which are sometimes referred to as direct or single-purpose project costs are costs of project features or facilities that serve a single purpose. For example, specific costs assignable to irrigation will include those of canals and distributaries with head-works or regulators and other features that are provided exclusively for purposes of irrigation. At times, there will be space in a jointly used reservoir which is assigned exclusively to a single purpose e. g. flood control.

(*ii*) *Separable cost* which are referred to as added or incremental costs for each project purpose, is the difference between the costs of the multi-purpose project and the cost of the project with that purpose omitted, i. e. the remaining project. The following are guiding criteria for

application in formulating the plans for the remaining project :

(*a*) The remaining project need not be justifiable on a benefit-cost basis.

(*b*) The remaining project must be located at the same sites, follow the same rates or otherwise be based on the same location as the multi-purpose project.

(*c*) It must be physically or engineeringly feasible of development.

(*d*) It should exclude all facilities used solely by the purpose omitted but should include unchanged all of the single-use project facilities and features of the remaining purposes included in the multi-purpose project.

(*e*) It should represent the most optimum size, design and plan for joint use facilities that would provide benefits to each of the remaining purposes, at least, equal to the benefits of each of those purposes in the multi-purpose project.

(*iii*) *Joint cost* is the cost of facilities used for two or more purposes and as such cannot be directly traced and assigned to a single purpose. Examples are costs of multi-purpose dams, reservoirs, irrigation-cum-navigation canals and tunnels, that are used jointly, or in common, for two or more purposes. Joint costs are defined as the difference between the costs of the multi-purpose project as a whole and the total of the separable costs for all project purposes, and thus represent a residual attributable to all or several purposes.

Project benefits are the estimated value of project effects comprising increases in production of goods and services and improvements in the general socio-economic conditions in the project-affected area. These again will fall into three classes, namely,

(*i*) *Direct benefits* from the increase in production of farm products; electric power; reduction of damages from floods, population and sedimentation; improvement of navigation, recreation and conservation of fish and wildlife; provision of domestic, municipal and industrial water supply ; and other increases in the immediate products or/and services.

(*ii*) *Indirect benefits* in activities flowing from or generated by, the project, consisting of increase in the production of goods and services other than those included in direct benefits.

(*iii*) *Public and intangible benefits* on which it is well nigh impossible to place monetary values and yet they are real benefits not entering into the process of cost allocations.

Principles of Allocation

Cost allocations are generally a matter of exercise in judgement. Generally speaking, the utilisation of one project structure or feature to cater for more than one service allows the services to be provided at less cost than the total cost of separate structures for each service. For this, the additional cost of providing each function as an addition to the other function of the combined structure or project features should be less than the cost of the most economical single-purpose alternative means of producing identical benefits for that function. This leads to a fundamental principle of cost allocation that the saving derived by the use of a combined structure for a variety of purposes or objectives should be shared equitably by the various purposes. There are certain benefit-cost relationships which must be recognised such as that no function be assigned costs in excess of its benefits or be supported by benefits attributable to another purpose. The allocation must be consistent with existing laws, treaties and compacts affecting the project plan. The following broad principles need to be applied :

(*i*) The cost of facilities used for a single purpose should be allocated to the respective purposes served by such facilities.

(*ii*) The minimum allocation to each purpose is its specific or its separable cost.

(*iii*) The maximum allocation to each purpose is the value of its benefits or the cost of alternative justifiable single purpose scheme providing the same benefits, whichever is less.

(*iv*) Each purpose should share equitably in the savings resulting from multiple purpose development within the limits of maximum and minimum allocations.

(*v*) Legal priorities for the use of water and existing laws, treaties and compacts must be recognised.

Methods of Allocation

Various methods of allocating costs are adopted, any one or a combination of several of which may be applicable in a particular situation. Cost allocation by all methods has a common procedure involving the following steps :

(*a*) Specific costs of facilities which serve only one purpose are assigned to that purpose.

(*b*) Joint costs are distributed among allocable purposes by one or more suitable methods.

(*c*) The total allocation to each purpose is the sum of the specific costs and the share of the joint costs assigned to that purpose.

The principal methods generally followed are briefly described below :

(*i*) *Benefits :* This method divides joint costs in proportion to net benefits received by each purpose from common expenditures. This is seldom used as it fails to consider the relevant alternative single-purpose costs which are important in determining the maximum allocation to a purpose. Furthermore the measurement of benefits has not been developed to the point of being a precise and reliable procedure.

(*ii*) *Alternative Justifiable Expenditure :* This method aims at apportioning joint costs in proportion to alternative justifiable expenditures for

each purpose, defined as the lesser of benefits and alternate costs for each purpose. The minimum allocation under this method is the specific costs. In theory and practice, this is believed to represant the more logical, adequate and dependable approach. This method was relied upon in allocating costs of Norris, Wheeler and Wilson dams by T. V. A. between flood control and power.

(*iii*) *Separable Costs—Remaining Benefits*: This method resembles closely the alternative justifiable expenditure method, except that the minimum allocation is determined by separable costs rather than specific costs. This includes within the minimum allocation a portion of joint costs as well as all specific costs. It requires more careful estimate of project costs than does the Alternative Justifiable Expenditure method; but both methods are reasonable and rational in theory. The U. S. Army Corps of Engineers recommend this for general use.

(*iv*) *Priority of Use*: This method assumes that interference between project purposes is not adequately reflected in estimates of benefits and of alternative single-purpose costs obtaining these benefits, even though the benefits are calculated on the basis of co-ordinated operation plan. In an attempt to allow for unpredictable interference, it assigns maximum allocations to highest priority purpose, such as municipal water supply and irrigation and may allow low priority purposes, such as power to be charged only specific costs. In practice, this method is used to allocate the maximum amount to interest-bearing power investment. In U.S.A., this method has been defended by the Bureau of Reclamation and universally attacked by other agencies as a preferential and inequitable procedure.

(*v*) *Residual*: This method is a variation of the Priority of Use method, whereby maximum allocations are charged to non-reimbursible purposes, irrespective of priority, such as flood control, navigation and recreation thus permitting only the reimbursible purposes to share in the savings of multi-purpose development. The Residual and the Priority of Use procedure are so vulnerable that they are rarely used alone and are generally disguised by averaging their results with those of more defensible methods.

(*vi*) *Use of Facilities* : This method distributes joint costs on the basis of physical use, such as storage capacity or water releases separately or in combination. It is susceptible of many variations and throws up problems in over-lapping use of space, dead storage and hold-over storage and time variations in use. Its distinguishing feature lies in the assumption that a unit of water has the same value for all purposes. This has limited application such as in dividing the cost of a canal between municipal drinking water supply and irrigation water on a capacity basis. It is useful in making sub-allocation on the simple basis of a proportionate use of a given facility as measured in physical terms. In U. S. A., I understand that the U. S. Corps of Engineers and Federal Power Commission do not favour this method for general adoption due to difficulty in establishing with validity the actual use made of joint facilities by the several functions on a comparable basis.

(*vii*) *Equal Apportionment* : This method is essentially a rule of thumb since it divides joint costs equally among all of the project functions. The result cannot be supported by benefits or the costs of alternative single-purpose project.

(*viii*) *Vendability* : The method has wide application in private industry where commodities are priced in a competitive market. With the possible exception of power, however, the project purposes are not subjected to a competitive situation. Hence, this method is considered inappropriate.

Application of Procedure

Now, taking a project estimated to cost Rs 76 crores, the application of some of the more commonly adopted methods and the major steps involved in arriving at the final allocations of the total cost for various purposes are illustrated in Annexures I-V. To get a comparative idea of the results from these various methods, the final allocations are summarised in the table below :

Rs. crores

S. No.	Method	Total cost	Allocation to		
			Irrigation	Power	Flood-control
(*i*)	Benefits	76.0	24.4	36.3	12.3
(*ii*)	Alternative Justifiable Expenditure		31.6	27.4	17.0
(*iii*)	Separable Costs Remaining Benefits		31.5	27.3	16.2
(*iv*)	Priority of Use		43.0	23.0	10.0
(*v*)	Residual		30.0	23.0	23.0

Annexures VI & VII exhibit the summary of results of applying the methods (*ii*), (*iii*) & (*iv*) under column (2) of the foregoing table, in the case of the Central Valley Project in California and the Weber Basin Project in Utah State respectively. These projects are now in various stages of construction and development in U. S. A.

Analysis of the various approaches may indicate that many of the methods have serious limitations for application to a project. The Benefits method is not defensible since the costs of alternative means of realising the same benefits are not considered. The physical nature of a project may be such as would make it difficult to apply the Use of Facilities method. Any allocation method using benefits at any stage is questionable from the point of view of the validity of the benefits which are the estimated value of the services or products from the project. In addition, there may be intangible benefits which may not lend themselves to evaluation in terms of rupees and naya paise but yet they are real benefits not entering into the process of cost allocations. The adequacy of the basic

da a used in estimating the alternatives for the single purpose is another drawback and their cost estimates may not carry the same degree of accuracy or reliability as the main project estimates. Ofcourse, these are matters of concern for aspects of the project development in addition to cost allocations and may affect project formulation and justification. However, they do not affect the application of the cost allocation methods. One view is that the Alternative Justifiable Expenditure or the Separable Costs Remaining Benefits method overcomes almost all these objections and is, perhaps, the most appropriate and suitable approach. The Separable Costs Remaining Benefits method may not yield equitable results if it is applied arbitrarily to a project where the scale of development for each purpose is decided upon other concepts such as maximum use of favourable site and has limited usefulness if applied in areas where the legislative background, the criteria employed in formulating, authorising and constructing the project etc., have to receive due recognition.

Conclusion

If the cost of a single purpose river valley project is to be met by charging beneficiaries from the project on the basis of capital cost, there is no allocation problem involved in apportioning the project cost. If, however, charges of a similar basis are to be met for all or some of the beneficial effects of a multi-purpose project, the allocation of cost chargeable to the several purposes of the project becomes necessary. In some cases, charges for the products from the project or services rendered may be so much that the value of the services rendered requires no cost allocation. In other cases, the public may meet the cost of the project through taxes in which case also, no allocation of cost among purposes may be necessary. If assessment is to be made on the basis of the value of the services rendered and without regard to the costs of providing the project services or products, no allocation of costs among the various purposes is needed. Assessment may be made in any of the ways leading to returns less than, or more than, the cost of the project. The data on project benefits and project costs obtained in the course of economic analysis of projects may provide the necessary basic information for determination of charges for project services by several of the methods. If benefits are used as a basis for assessment, it may be necessary to adjust project benefits to reflect the local incidence of project effects which may have been offset or nullified in computing the benefits creditable to the project from a public view-point. Also, an allowance may need to be made for private evaluation standards in so far as they may differ from public evaluation standards.

This paper, by no means comprehensive and exhaustive, is an upshot of the studies the author had the good fortune to be engaged on during his visit to U.S.A. in 1956. If the paper had helped to make the reader get an idea of the various possible methods of allocation of costs of multi-purpose river valley projects and the broad principles and procedures thereof, it would more than have served its purpose.

Note: Whatever Suggestions and views have been put forth in the paper are the auther's own and does not commit the Government or the Planning Commission in any way.

ANNEXURE I

Benefits Method

(*Rs. Crores*)

Item	*Total*	*Irrigation*	*Power*	*Flood control*
Annual Net Benefits (1)	4.5	2.0	1.6	0.9
Capitalised Net Benefits (2)	164.7	73.2	58.6	32.9
Less Specific Costs (3)	23.0	—	23.0	—
Remaining Benefits (4)	141.7	73.2	35.6	32.9
Percent of Remainings Benefits (5)	100.0	51.7	25.1	23.2
Allocation of Joint Costs (6)	53.0	27.4	13.3	12.3
Addl. specific costs(7)	23.0	—	23.0	—
Allocation of Total cost	76.0	27.4	36.3	12.3

(1) Benefits for making allocation consist of net benefits which are obtained by deducting private costs and project costs from gross benefits.

(2) Capitalised annual net benefits multiplied by 366 the factor for present worth of an annuity of 1 per year for 100 years at 2½%.

(3) Specific costs for each purpose are credited with the portion of total net benefits which they produce by subtracting specific costs from net benefits.

(4) Since contribution of joint costs in producing benefits is unkown remaining benefits are derived on the assumption that specific costs produce benefits in equal proportion.

(5) Percent of remaining benefits is determined for each purpose. In case of irrigation, for example, the determination would be Rs. 73.2/- 141.7 or 51.7 per cent.

(6) Joint costs are apportioned in the ratio of remaining benefits of the various purposes.

(7) Specific costs are added to allocation of joint costs to obtain allocation of total costs.

ANNEXURE II

Alternative Justifiable Expenditure Method

(*Rs. crores*)

Item	*Total*	*Irrigation*	*Power*	*Flood control*
Annual Net Benefits (1)	4.5	2.0	1.6	0.9
Capitalised Net Benefits (2)	164.7	73.2	58.6	32.9
Cost of Alternative(3)	95.0	43.0	29.0	23.0
Alternative Justifiable Expenditure (4)	95.0	43.0	29.0	23.0
Less specific costs (5)	23.0	—	23.0	—
Remaining Justifiable Expenditure (6)	72.0	43.0	6.0	23.0
Percent of Remainder (7)	100.0	59.7	8.3	32.0
Allocation of Joint Costs (8)	53.0	31.6	4.4	17.0
Add specific costs (9)	23.0	—	23.0	—
Allocation of Toatal cost	76.0	31.6	27.4	17.0

(1) Same as for Benefits Method (Vide Annexure I)

(2) Same as per Benefits Method (do -)

(3) This is the cost of the most economical single purpose project in the area that would provide net benefits equivalent to those created for that purpose by the multiple purpose project.

(4) The alternative justifiable expenditure for each purpose is the lesser of two amounts : (*a*) the most economical alternative, and (*b*) the capitalised net benefits.

(5) Specific costs which serve particular purposes in the multi-purpose project are respectively deducted from the alternative justifiable expenditure for each purpose.

(6) Item 4 minus item 5 gives item 6.

(7) Percent of remainder is determined for each purpose, irrigation, for example : Rs 43.0/72.0=59.7 per cent.

(8) Joint costs are apportioned to each purpose according to the percent of remainder.

(9) Specific costs for each purpose are added to the apportionment of joint costs for that purpose to give the total allocation by purposes.

ANNEXURE III

Separable Costs—Remaining Benefits Method

(*Rs crores*).

Item	*Total*	*Irrigation*	*Power*	*Flood control*
Annual Net Benefits	4.5	2.0	1·6	.9
Capitalised Net Benefits	164.7	73.2	58.6	32.9
Cost of Alternative	95.0	43.0	29.0	23.0
Alternative Justifiable Expenditure (1)	95.0	43.0	29.0	23.0
Separable Costs (2)	62.0	23.0	20.0	13.0
Remaining Benefits (3)	33.0	20.0	3.0	10.0
Percent of Remaining Benefits (4)	100.0	60.6	9.1	30.3
Allocation of Joint Costs(5)	14.0	8.5	1.3	4.2
Add separable costs (6)	62.0	23.0	26.0	13.0
Allocation of Total cost	76.0	31.5	27.3	16.2

(1) The alternative justifiable expenditure for each purpose is the lesser of the most economical alternative and the capitalised net benefits.

(2) The separable costs for each project purpose is the difference between the cost of the multi-purpose project and the cost of the project with the purpose omitted.

(3) Remaining Benefits—Item 1—Item 2.

(4) Percent of each item in line 3 to their total

(5) Each purpose is charged with joint costs equal to the percent of its remaining benefits.

(6) The separable costs and assigned joint cost for each purpose are added to obtain the total allocation to that purpose.

ANNEXURE IV

Priority of Use Method

(*Rs. crores*)

Item	*Total*	*Irrigation*	*Power*	*Flood control*
Annual Net Benefits	4.5	2.0	1.6	.9
Capitalised Net Benefits	164.7	73.2	58.6	32.9
Cost of Alternative	95.0	43.0	29.0	23.0
Alternative Justifible Expenditure	95.0	43.0	29.0	23.0
Less specific costs	23.0	-	23.0	-
Remaining Justifiable Expenditure	72.0	43.0	6.0	23.0
First Priority		43.0		
Second Priority				10.0
Third Priority			none	
Allocation of Joint costs	53.0	43.0	—	10.0
Add specific costs	23.0	-	23.0	-
Allocation of Total cost	76.0	43.0	23.0	10.0

In the priority of use method, specific costs are assigned to the individual purposes served and joint costs are assigned in turn to allocable project purposes in the descending order of priority. Joint costs are charged to the purpose of top priority in an amount equal to the lesser of: (1) capitalised net benefits less specific costs assigned to that purpose, or (2) the cost of the most economical alternative single-purpose project less specific costs assigned to that purpose from the multiple purpose project. The remaining joint costs are then assigned by repetition of the same procedure to the purpose of next highest priority and other purposes in turn. In cases where all joint costs are assigned by successive deductions to several purposes of high priority, purposes of lower priority are only charged with specific costs.

ANNEXURE V

Residual Method

(*Rs. crores*)

Item	*Total*	*Irrigation*	*Power*	*Flood control*
Annual Net Benefits	4.5	2.0	1.6	.9
Capitalised Net Benefits	164.7	73.2	58.6	32.9
Cost of alternative	95.0	43.0	29.0	23.0
Alternative Justifiable Expenditure	95.0	43.0	29.0	23.0
Less Specific Costs	23.0	—	23.0	—
Remaining Justifiable Expenditure	72.0	43.0	6.0	23.0
First Priority (1)				23.0
Second Priority		30.0		
Third Priority			None	
Allocation of Joint Costs	53.0	30.0	—	23.0
Add Specific Costs	23.0	—	23.0	—
Allocation of Toatl Cost	76.0	30.0	23.0	23.0

with this method, joint costs are assigned to purposes in the nonreimbursible category, such as flood control, navigation, and conservation of fish and wildlife, in an amount equal to the lesser of: (*a*) capitalised net benefits less specific costs assigned to that purpose, or (*b*) the cost of the most economical alternative single-purpose project less specific costs assigned to that purpose from the multi-purpose project. The remaining joint costs are then distributed to reimbursible purposes, such as municipal or industrial water, irrigation and power in descending order of priority.

ANNEXURE VI.

Central Valley Project, California

Comparison of Allocation of Costs by different methods.

(*Million Dollars*)

S. No.	*Purpose*	*Separable Costs-Remaining Benefits Method.*	*Alternative justifiable Expenditure (AJE) Method*	*Priority of Use Method*	*Average of Priority of Use and AJE*
1	2	3	4	5	6
1.	Irrigation	384.6	410.0	458.0	434.0
2.	Municipal & Industrial Use	17.4	17.3	7.3	12.3
3.	Power	292.2	272.5	200.5	236.5
4.	Flood-control	35.7	30.9	56.0	43.4
5.	Navigation	12.9	11.5	20.9	16.3
6.	Fish & Wild Life				
	(*i*) Reimbursible	2.7	3.2	2.8	3.0
	(*ii*) Non-reimbursible	11.6	11.7	11.6	11.6
7.	Recreation	0.2	0.2	0.2	0.2
	Total cost of project	757.3	757.3	757.3	757.3

ANNEXURE VII.

Weber Basin Project, Utah

Comparison of Allocation of Costs by different methods

(*Million Dollars*)

S. No.	*Purpose*	*Separable Costs-Remaining Benefits*	*Alternative justifiable Expenditure (AJE)*	*Priority of Use*	*Average of Priority of Use and AJE*
1	2	3	4	5	6
1.	Floodcontrol	4.2	4.9	7.4	6.2
2.	Irrigation	46.9	44.1	39.0	41.5
3.	Municipal & Industrial use	14.5	15.0	20.8	17.9
4.	Recreation	3.0	4.6	1.4	3.0
5.	Fish and Wild life	1.7	1.7	1.7	1.7
	Total cost of Project.	70.3	70.3	70.3	70.3

Record Tunnelling In Australia's Snowy Mountains Scheme

By W. P. GOODWIN.

World records were broken with the final breakthrough of the 24-feet diameter 14-mile Eucumbene-Tumut Tunnel through Australia's Great Dividing Range on August 26, 1957, only 2¼ years after commencement of the work.

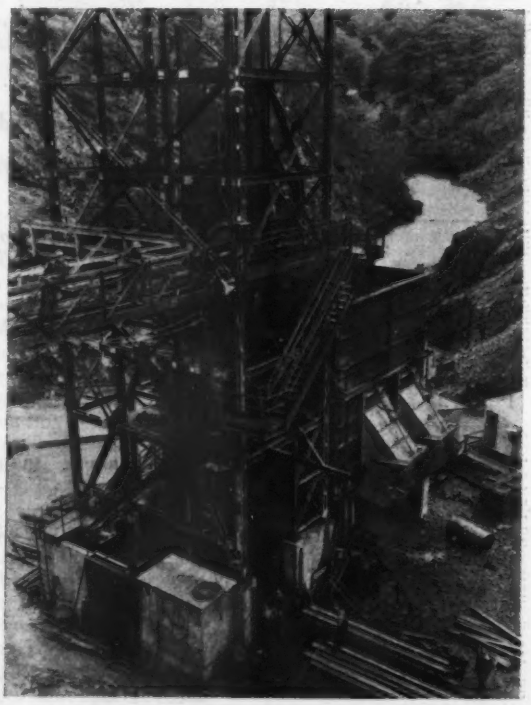
The tunnel is a vital link in the Snowy Mountains Hydro-electric Scheme to divert the south-flowing snow water of the Snowy River from east to west through the mountains of southern New South Wales into the River Murray system. The completed scheme, estimated to cost some £A422,000,000 will ultimately provide 1,818,000 acre-feet of water per annum, and will bring about for the first time in Australia the large-scale use of the waters of a coastal river on the dry inland, and in addition, will provide 2,770,000 kilowatts of peak-load electric power to be fed into the inter-connected systems of New South Wales and Victoria.

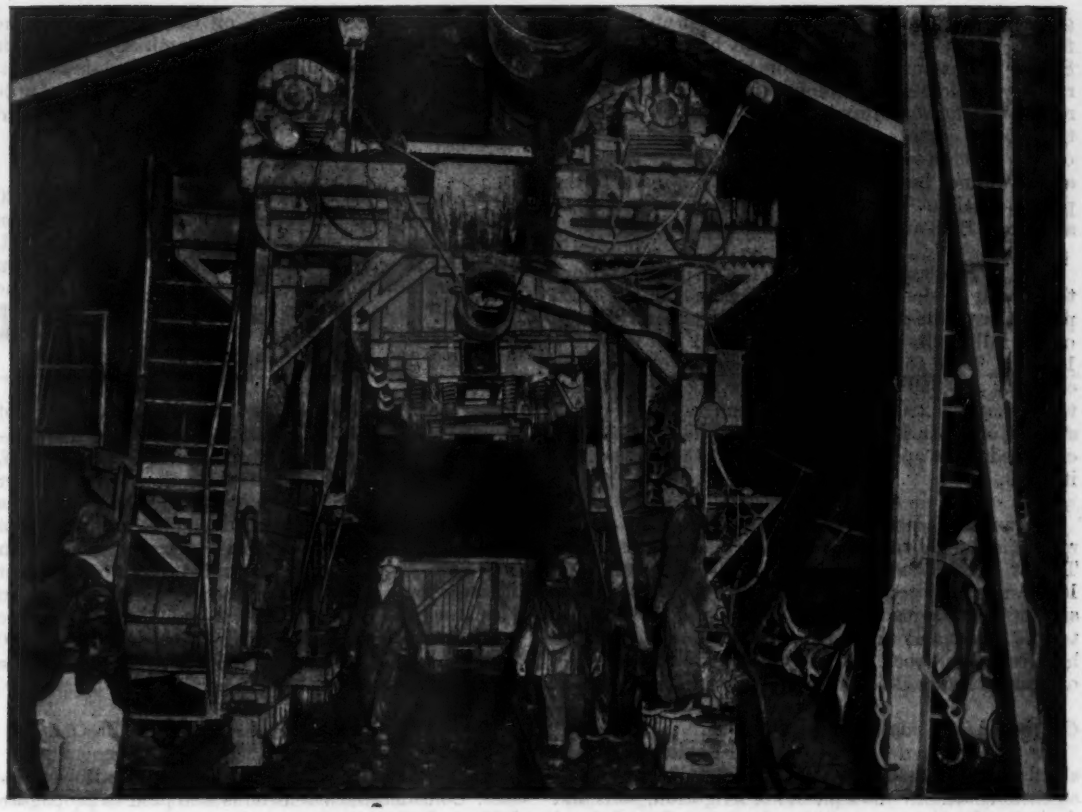
The Eucumbene-Tumut tunnel, the first trans-mountain excavation of the scheme, was made by the American group of contractors, Kaiser-Walsh-Perini-Raymond. Due to its depth beneath the Range, an access shaft to expedite operations by opening up two additional working faces could be sunk economically only at the confluence of the Tumut and Happy Jack rivers, leaving four miles of tunnel to be driven to the Tumut river, a tributary of the river Murray, and 10 miles to the Eucumbene river, a tributary of the Snowy river, which rises from the Snow of Mount Kosciusko, Australia's highest point, and flows southwards through Victoria into Bass Strait.

The sinking of the 300-feet Junction Shaft was begun in February, 1955, and completed the following year. At the same time, work began at Eucumbene Portal and advanced 16,000 feet by June, 1956, while 564 feet of tunnel was driven from the Tumut end. With the completion of Junction Shaft, the work proceeded rapidly and, on June 27, 1957, the breakthrough occurred in the four-mile section, to be followed two months later by that in the 10-mile leg.

The last 14 feet of rock were demolished when the Premier of New South Wales, Mr. J. J. Cahill, and the Premier of Victoria, Mr. H. E. Bolte, heads of the two States immediately affected, pulled a switch to explode 600 lb. of gelignite. Also present was the Federal Minister for National Development, Senator W. H. Spooner. This concluded a performance during which the tunnellers drove more than 400 feet in one six-day working week on no less than 24 occasions, including the world speed record for tunnelling of 484 feet. The average progress achieved of nearly six miles a year (14 miles in 2¼ years) compares with the 11 years, at an average of one mile a year, required to complete in 1906 the 12 mile Simplon Tunnel through the Alps. More recently, the Cascade Tunnel in the United States was completed in 1929 at the then record of almost two miles a year.

A junction shaft used to deliver workers and material to a 14-mile tunnel through mountains.





A "jumbo" mechanical miner burrowing through a mountain

The Snowy Mountains Authority was responsible for giving the contractor line and level for all tunnel work. The check survey after the four-mile section was holed through revealed an error of only ¼ in. in direction, ⅜ in. in height and ⅜ in. in distance. This accuracy is all the more notable because the survey was taken from the small area of a shaft 300 feet from the surface.

The new tunnel has now to be lined with concrete, a job which is expected to take some 18 months, before it will function. Meanwhile, the Eucumbene waters are beginning to collect at one end of the tunnel in the Adaminaby Reservoir, which is already nearly one-quarter full following the closing of the diversion gates at the Adamina by dam in June, 1957. This dam, which is also being constructed by the Kaiser-Walsh-Perini-Raymond group, will be one of the highest earth and rock fill dams in the world. When completed, it will be half a mile thick at the base and 380 feet high and will store 3,860,000 acre-feet of water, more than eight times the volume of Sydney Harbour. The dam is already half constructed and will probably be completed within two years of the commencement of work on it, compared with four years allowed under the contract. This largest storage of the Snowy Scheme is scheduled to be in service by the end of 1959, enabling at first an average of 300,000 acre-feet of water annually to be supplied to the irrigation areas of the Murrumbidgee River (a tributary of the Murray valley. By 1962, this will be increased to 500,000 acre-feet.

This water will discharge from the Eucumbene-Tumut tunnel into the Tumut river at a point where it is being dammed so that the power potential can be tapped. In a steep gorge just downstream from the tunnel outlet, the same American contractor group has completed the foundations of the 290 feet high arch concrete dam, which will control the flow of four rivers—the Tumut, the diverted Eucumbene, the Upper Murrumbidgee and the Tooma. Surplus water during heavy rainfall periods from the Tumut and the Tooma will be fed back through the Tunnel to the Adaminaby Reservoir for storage by raising the level of water in Tumut Pond, the storage capacity of which will be 43,000 acre-feet. Normally, however, all waters will flow into a 1½ mile tunnel through a spur in the mountain-side to fall down two vertical pressure shafts some 1,000 feet to the turbines of a 320,000 kilowatt power station, T. 1., situated in a cavern excavated from the solid rock by a French contractor group. Completion of the Tumut Pond Dam and the 1½ mile pressure tunnel is scheduled for 1958. Excavation of a third shaft, to provide access to the station by means of a lift well, is also nearing completion.

Work on the T. 1., Station began in 1954. The full roof arch of the machine hall, 300 feet long and 76 feet wide, has been concreted and excavation, working downwards, has reached the level of the unloading bay, some 50 feet below the top of the arch. Excavation of the transformer hall is almost complete. Orders for four 120,000 h. p. turbines and four 80,000 kilowatt

generators have been placed with English and Swedish firms. These great machines will be hauled by the Snowy Mountains Authority some 70 miles from Cooma railway station into the mountains to the new Authority town of Cabramurra, 4,880 feet above sea level, then down a steep access road hewn from the rock of the precipitous Tumut River gorge to the short access tunnel beside the swiftflowing stream to the power station. The first two units are to come into service in 1958 and the remaining two in 1959.

T. 1., is the first of five hydro-electric power stations to be built on the Tumut river. Tenders for the T. 2., project are to be called in 1957. It will take advantage of the fall in the river from T. 1., and will involve a 140-feet high concrete gravity dam with a storage capacity of 1,350 acre-feet of water, about 6½ miles of tunnels and a 280,000 kilowatt underground power station, of which two units of 70,000 kilowatts each are expected to be operating in 1962 and the second two in 1963.

An associated work, designed to provide a high rate of draw down in order to increase the value of Tumut Pond Reservoir, is also to be undertaken in 1957 and completed by 1960. It provides for diversion of the Tooma River, a tributary of the Murray, to the Pond and involves construction of a 222-feet high earth and rock fill dam to store 22,200 acre-feet of water and a 13-feet diameter nine-mile tunnel. Work should begin in 1958 on the diversion of the Upper Murrumbidgee to the Adaminaby Reservoir by constructing a 160-feet high concrete dam at Tantangara to hold 200,000 acre-feet. This and a 10 mile long, 10-feet wide diversion tunnel are to be completed in 1961.

The Scheme as a whole, which will take about 20 years to complete involves the construction of seven major dams; 15 power stations, mostly underground; 83½ miles of tunnels varying in size up to 30 feet in diameter; more than 330 miles of racelines along the mountain sides; shafts ranging up to 1,100 feet in depth; and some hundreds of miles of mountain roads in rugged and hitherto inaccessible country.

The Scheme falls roughly into two sections, one of which—the Eucumbene-Tumut—has just been indicated. The other the Snowy-Murray—more to the south, is still in the survey and investigational stage, other than the first completed project at Guthega, on the upper Snowy River. This involved the building by a Norwegian contractor of a mass concrete gravity dam 110 feet in height to form a pondage of 1,260 acre-feet of water, which flows through a three-mile tunnel to a penstock at Munyang 720 feet above the river, thence to a power station. Two of the latter's three 30,000 kilowatt generators have been installed and have operated since February 1955.

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Regional Irrigation Practices Seminar

should also be taken to provide specialised training at various centers in all phases of irrigation, soils and drainage for work on national, regional and local levels.

Another important factor noticed in Turkey is a large-scale irrigation extension service. The irrigation extension service in Turkey has become a highly effective organisation for effecting increased yield of agricultural produces through efficient and economic use of irrigation water. The irrigation extension services personnel not only carry out research to determine water requirement of crops, efficient field distribution methods, fertiliser requirements, but they also assist and guide the farmers in selecting a proper cropping pattern, land levelling, sound distribution system and optium use of water, time and quantum of manuring and in adopting good cultivation practices. Considerable attention is also paid to propagate the knowledge through movies and posters, the importance and advantages of improved irrigation and manurial practices.

Though the major part of Turkey is rugged and hilly, the farmers had been working very hard to introduce contour farming and terracing.

In Turkey, there is practically no steel manufactured there. To conserve the use of steel and to restrict imports we noticed extensive use of wooden poles for telegraph, telephone and transmission towers. Factories, multistoreyed buildings and major construction works were mostly built with reinforced concrete and not with steel.

Central Board of Irrigation & Power Conference at Roorkee

Regional Irrigation Practices Seminar

By D. MOOKERJEA

In September 1956 I was deputed by the Government of India at the instance of the Government of West Bengal to attend the Regional Irrigation Practices Leadership Seminar held at Turkey under the auspices of the International Co-operative Administration, USA. I left Calcutta on August 29th, 1956 and after spending a couple of days at Istanbul arrived at Izmir, a district Headquarters of Turkey, opposite Athens in Greece on September 1st.

Twentynine delegates attended the Seminar. The delegates from India were Sri M.P. Mathrani, Chief Engineer, Bihar and myself.

The objectives of the Seminar were :

(*a*) To create an interest among the participants in the need for initiating modern irrigation and agricultural practices in their own countries.

(*b*) To provide a forum for discussion among the participants regarding the proposed programme to be followed in each country in irrigation and agricultural practices.

(*c*) To emphasise the urgent need for creation of a balanced irrigation agriculture training and creation of a suitable irrigation extension service to further the policy of sound irrigation practices.

The papers presented in the Seminar centered round the following subjects :

1. Irrigation efficiency
2. Irrigation methods
3. Drainage investigation and relation of drainage to irrigation.
4. Efficient water use
5. Irrigated farming
6. Extension personnel to work with the farmers.
7. Proper training needs.

Group discussions were also held and panel reports were presented on the following subjects :

1. Land preparation factors and farm irrigation equipment.
2. Irrigation Research as related to efficient irrigation practices.
3. Land classification, water requirement and drainage
4. Extension Service Operations program and technician training.
5. Farm water delivery and irrigation system operations.

We were taken round some demonstration centers and an Irrigation Experiment Station as well as to visit actual construction of some river valley projects in Gediz Valley and Demikopru Dam. Practical demonstration of use of locally made and imported irrigation equipments was arranged. It was also impressed on the delegates how the crops response to proper land preparation and increased yield by making better use of irrigation water is significant.

In course of group discussions the following important conclusions were drawn up :

(*i*) what is urgently needed is the development of farmer interest in improvement of irrigation system through a network of extension service ;

(*ii*) irrigation research both in the engineering phase as well as in the agricultural phase should be intensified. Effective steps must be taken to see that the information obtained from research works are passed on to the farmers through extension service and publications in local languages ;

(*iii*) purchase and operation of large machines and equipments should be encouraged by co-operative agencies. It was felt that these co-operatives should be encouraged to train technicians and operators in the proper and efficient operation and maintenance of the equipments. Since most of the farmers have very small holdings and are poor, faster progress will be attained by educating them in the use of light and locally made equipments ;

(*iv*) A basic set of land classification standards be established. If such survey is not already available a reconnaissance land classification survey should be completed before too much project planning is advanced ;

(*v*) A more comprehensive knowledge of water requirements for various crops grown is essential to plan better farm irrigation system and drainage system. Each country should carry out actual research work for various crops and different periods of irrigation for all types of irrigation efficiencies ;

(*vi*) it is essential to determine the relationship of drainage to irrigation and to carry out detailed drainage investigations ;

(*vii*) each country should establish as soon as possible an appropriate organisation for dealing with matters of irrigation, drainage and soils and the organisation should be set up in such a level that it can provide technical assistance to farmers in irrigation, drainage, soils and soil conservation. Steps

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World Power Conference—11th Sectional Meeting

The 11th sectional meeting of the World Power Conference Meeting was held at Belgrade on June 5th in the newly constructed Trades Union Building. Mr. Edward Kardelj, Vice-President of the Yugoslavia Federal Executive Council, in his opening speech, paid tribute to the work of the World Power Conference for the last 30 years towards international co-operation in questions relating to energy. He laid particular stress on the present session as an effort to narrow the gap between the highly industrialised and the under-developed countries. There were over 500 delegates from 51 countries, large and small. The Meeting was devoted entirely to a study of the needs of under-developed areas and from the discussions and opening speeches it was apparent that the more technically advanced countries were aware of the difficulties facing their less fortunate brothers and of the need to help them by suggesting ways in which their energy problems may be solved.

Sir Harold Hartley pointed out that at the past meetings evidence of increased productivity from the use of energy had come from the highly industrialised countries. But it was a function of the Belgrade Meeting to find out how far these findings could be applied to the less developed countries which had not so far been able to take advantage of progress in scientific research. Power was only a means to an end, that end being the most effective utilisation of the indigenous resources of each country. The problems of mechanisation of both industry and agriculture, and the relation of men to the machine, needed careful study ; sometimes work could be done better by manual labour than by a machine. Circumstances in each country would decide the question whether the objective should be a rapid transition to the automatic factory, cutting out the intermediate stages through which the older countries had passed, or a fresh stimulus to village industries by provision of power and transport.

The development of industry should be based as far as possible on indigenous raw materials and surveys were needed to evaluate the resources. The transport of fuel over long distances was costly and consequently the possession of adequate energy resources would have a decisive effect on a country's immediate evolution but, in the future, nuclear power should become increasingly available at an economic cost.

Dr. H. J. Bhabha, Chariman of the Indian Atomic Energy Commission pointed out that while adequate power was needed, a balance must be struck when capital resources were limited ; there must be enough capital to finance the industries needed to use this power. If hydro power were available from perennially flowing rivers, without involving excessive civil engineering, this was the cheapest power available and it should be developed regardless of other considerations if close to where the power could be used.

Atomic power stations, the capital cost of which was certain to be high, must operate on high load factors for economy and must, therefore, be able to feed their output into a grid. They might therefore have only limited scope in under-developed areas owing to the wide dispersion of the population, although the total load might be larger. Factors determining this scope varied greatly from country to country.

As the discussion proceeded it appeared that conflicting views on the financing of power schemes were expressed by Mr. W. L. Cisler and Mr. Gunnar Myrdal. Mr. Cisler thought that power schemes should always be self-supporting without the need for subsidies. While Mr. Myrdal felt that national planning in these backward areas could not always be done in terms of costs and profits of individual enterprises. It might be wise in his opinion to undertake schemes in spite of their not appearing remunerative according to private business calculations.

With further discussion of the issue it could be noticed that while experience of industrialised countries was of interest to the under-developed areas, the degree of its application was dependent upon the present state of development of an area, upon its physical situation, its climate and other factors. When the present development was not too far behind than in more advanced countries, their experience could be applied advantageously—as perhaps in Yugoslavia itself which is on the threshold of industrial development. Where, however, development has hardly begun, or has not begun at all, the problems are so different that this experience may not be very helpful—unless, indeed,

the necessary capital were available for a complete scheme of rural electrification. Even then there would be the question of load building and the prospect of a lenghyt delay before the inhabitants could afford a high consumption of energy.

The use of small local generating stations would seem to be a first in development in many of the quite extensive areas which could be much more fully developed for agriculture. This has been recognised in the U.S.S.R. which already has large number of such stations. It is very expensive to import energy, in not very large quantities, for each district from the nearest large generating stations and the transport of oil for diesel generation is also costly when the distances involved are great and the roads are bad. Failing a small, easily operated, "packaged" nuclear power plant of (say) 10 to 100 kW capacity which is not likely to be available for many years to come, there is scope for such local energy resources as wind, solar radiation, small scale water power and vegetable wastes.

The preparations for the meeting were in the hands of a committee with Prof Dusan Velickovic of Belgrade University as the Chairman. The next sectional meeting has been decided to be held in Montreal in September 1958. Its subject will be economic trends in the production, transportation, and utilisation of fuel and energy.

Prospects of Nuclear Generation in under-developed Countries: Discussion at World Power Conference

The porspect of nuclear generation in countries at present under-developed formed a subject of discussion in the World Power Conference sectional meeting at Belgrade. Mr. J. C. Duckworth of the Central Electricity Authority, U.K., surveyed the papers that were submitted on the question and reported that he found no general agreement regarding types that were likely to capture the market.

In determining the economic factors, which should predominate, the first need was to assess a practical rate of progress in a country's general level of industry, and then to consider what conventional power sources were available, the cost of putting them into the reactor service and the probable trend of fuel prices.

A number of manufacturers could quote firm prices for such reactors as were out of the experimental stage. The present high capital cost of nuclear plants placed them at a disadvantage at the low load factors to be expected in non-industrial countries and their ability to cope with daily load fluctuations was still doubtful. Furthermore, the cost per kW rose steeply with reduction in size of reactor. Nuclear training of operating staff would not be required before commitment to a project, but a preliminary need would be to build up a technical staff with experience in general engineering.

Mr. J. A. Jukes of UK, AEA, compared by statistics the alternative base-load power stations in the United Kingdom at the present time. He expected the capital cost per kW of the second group of graphite-moderated gas-cooled natural-uranium reactors of the C. E. A. stations to be possibly 15 per cent lower. A 50 mW reactor might cost 50 per cent more.

Table 1.—Comparison of Costs of Generating Electricity

	Pence per kWh sent out		
Capital charges... ...	0.40	0.13	0.09
Inital fuel charge	0.05	—	—
Works costs	0.05	0.05	0.04
Fuel costs	0.22	0.42	0.74
Gross generating costs	0.72	0.60	0.87
Less plutonium credit	0.06	—	—
Net generating costs	0.66	0.60	0.87

Table 2.—Description of Stations and Assumptions on Performance

	Nuclear	*Coal Fired*	*Diesel*
Output	300MWs.o.	200MWs.o.	10MWs.o
Capital cost per kws.o	£135	55	£36
Thermal efficiency, per cent	27	34	—
Load factor, per cent	75	75	75
Life of plant, years	20	27½	25
Rate of interst, per cent	5	5	5
Initial fuel charge	500 tons	—	—
Irradiation level	3000 MWD/T £18,000	—	—
Cost of fuel/ton	£4.6.0 per gram of purified metal	£4.3.0	£12.10.0

The value of the initial fuel was assumed not to vary throughout the reactor's life, the whole cost being included in replacement costs, so no amortisation charge was allowed for. Transport costs of nuclear fuel from the reactor for reprocessing would be higher than they were to the reactor owing to the heavily shielded containers necessary for the irradiated elements ; these weighed from 30 to 50 times as much as the uranium. Even so they were still low, since a ton of uranium gave 10,000 times more heat than a ton of coal, and were almost negligible in comparison with costs of fabricating uranium elements and removal of fission products after use. Enriched fuel would cost more but would permit the use of a reactor system with lower neutron economy and higher heat output per ton of fuel and hence a lower capital cost. The high cost of a processing plant with necessary throughput of well over 1,000 tons/annum would prevent its economic use in a country without a highly developed nuclear programme, since a 300 mW reactor required only 100 tons of fuel a year for replacement.

No reactor of proved reliability and capable of producing power economically in small power ranges of, say, 20 to 50 mW or 1 to 10 mW was likely to be available for at least ten years. To illustrate the possible performances of such hypothetical reactors using enriched uranium, costs per kWh were worked out for 10 mW and 20 mW nuclear power stations operated at 75 and 25 per cent load factor. This indicated 1·29d and 2·31d as possible figures for the smaller station and 0·95d and 2·05d for the larger.

Dr. H. S. Arms (English Electric, Babcock & Wilcox and Taylor Woodrow Atomic Power Co.) suggested that initial training and refresher courses in

nuclear power techniques would be best obtained by the country concerned through sending selected men abroad, but research reactors (not of the type designed to produce power commercially) would also be required at home. Nine types of power reactors now being developed were described. Countries potentially wealthy enough to embark on largescale industrialisation would wish for secure and continual supplies of nuclear fuel, which could be obtained by installing natural-uranium gas-cooled graphite-moderated reactors (which required no diffusion plant), the techniques of which were well known. Small demands for power in remote areas might be met by "packaged" reactors, such as the pressurised water or boiling water types now under development (which were described in two U.S.A. papers). Production costs of these were likely to be high, but they might enable a local valuable asset to be exploited, such as a mineral deposit, where fossil fuels were unobtainable locally. High costs might not be of the first importance; in the Arctic generating costs were said to be from 17d to 26d/kWh.

In Canada where natural uranium was plentiful, no enrichment of fuel was contemplated (Messrs. N.S. Spence and J. Convey). A 200 mW (Power rating) reactor was scheduled for operation this year to provide testing facilities and also plutonium. It would use heavy water as moderator and coolant. Aluminium alloys, formerly considered corrosion resistant in water only below 150 deg C, now promised to be useful at over 250 deg C, and attractive in cost for some types of reactor.

A design of an organic moderated reactor, using a liquid polyphenyl as moderator, reflector and primary heat-transfer medium, was described by Dr. C. Starr (U.S.A.), who estimated the cost per kWh for a 12.5 mW plant at 16 mils per kWh and for a 150 mW plant at 10.3 mils.

Mr. S. Okita (Japan) dealt specifically with Asia and the Far East (ECAFE) the population of which formed 50 per cent of the world total but had only 10 per cent of the world's income. His view was that, owing to the large output for which economical reactors had to be built and to the low load factors obtainable in early stages of supply systems, reliance should be placed initially on conventional power resources, especially water power, if any, in combination with irrigation schemes. Greater immediate benefits might accrue from nuclear fission through radio-isotopes in agriculture and for medical uses. Atomic energy should be left until local power systems had expanded considerably, since the capacity of any generating station connected to them should not exceed 10 per cent of the whole. Technique, fuel and capital would generally have to be imported, and too early an introduction of nuclear power might cause excessive dependence on foreign countries. Financial assistance from advanced countries would be necessary for this purpose, a substantial part of which would desirably be channelled through an international agency.

Information from Poland was that the first nuclear power station (of 200 mW) would be erected there in 1965, to be operated in conjunction with stations fired with coal and lignite.

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GUJRAT

Estimated and Actual Costs

Quite a large number of river valley projects in India, big and small, have been completed and many more are under execution. This programme of national development is bound to continue for decades to come.

It has been a regular feature of these projects that few of them keep to the original project estimates by the time they are completed. This has been true both in the case of large inter-State projects as well as the smaller ones limited within the bounds of a single State. Thus at the stage of sanctioning of the estimates of a given project the legislators and the Government concerned go by one impression of the costs involved but as years pass, they have to sanction additional funds over and above the original estimates for one reason or the other and this creates a most confusing and unhealthy atmosphere both among the general public as well as their representatives.

It is time, therefore, that a general review and study of the causes and factors that have been responsible for such rises in costs of projects executed so far all over the country be made by a suitable Committee, and out of such a study it might be possible to formulate certain broad policies for guidance in the future, so that these large discrepancies be reduced to the minimum, or at least the avoidable causes are removed. The Planning Commission has time and again asked that greater and greater emphasis should be laid on detailed investigations and estimating of projects by the State Governments before these are sent up for consideration by the Commission and, to our knowledge, the situation is far better than even a couple of years back. Even so this aspect needs to be constantly kept in view and a clear analysis of past behaviour in the generality of cases would go a long way to keep a vigilant eye on the exact weak spots disclosed by a study of our past patterns of behaviour.

Apart from the cost aspect of the project, the ratio of the cost with the benefits that will accrue from the given project is an important factor. At the initial stage of this project when it is first sanctioned, the ratio may be so favourable as to make the project acceptable for inclusion in the budget. But as the costs go up, it is pertinent to enquire whether the cost-benefit ratio is maintained or not. Otherwise the original criteria of judgement and selection proves to be a false standard, and a less economic or justifiable project gets included in the budget at the cost of a more economic one. This often happens to be the case, as more than purely engineering factors become involved in the matter in the race for regional development sharing only a limited capital resources and foreign exchange priorities.

The idea behind suggesting such a study is not chiefly to find fault and apportion blame in each specific case. There is no point in raking up old controversies and harping on old themes. The approach to the matter should be to try to sum up our total experience and to analyse where generally lies the main causes of the trouble, so that in our future endeavours our estimates are more realistic from the very start and our cost-benefit ratio remains steady in case of each project throughout the period of its execution. Such a study will be immensely educative not only to the Planning Commission but also to the engineers and the legislators in each State.

* * * * *

River Valley Development in Soviet Union

River Valley development in our country has come to stay as a permanent feature of our programme of national development. For over a decade now work has been going on on a grand scale comparable in scope and quality to any other country in the world. We have by now become accustomed to a pattern of behaviour in the mater of selection, investigation and execution and all the problems and controversies implied in such a programme.

Compared with this background, the study of the Soviet experience contained in the book "Soviet Waterways" by Andrei Lebed and Boris Yakovlev published by the Institute for the Study of the USSR, Munich, provides a revealing contrast. On the one hand the book gives brief outlines of the major river valley projects in European and Asiatic Russia with a large number of maps and sketches which shows not only that in the last 40 years a tremendous advance has been made but also that the future projects are indeed breath-taking and awe-inspiring. On the other hand the methods and policies adopted in the matter of their execution give us a creeping sensation and indicate the contrast between our practices and policies and theirs.

The authors have carefully documented all their statements mainly relying on Soviet publications, but even so they complain that factual data both about the projects and about their execution are not always available. Why should this be so we fail to understand. But their trend of arguments indicate that partly this is due to the strategic concept in their planning and partly in order to cover up the errors and mistakes of the engineering departments concerned.

Another important aspect mentioned by the authors is that no substantial literature is available regarding costs and benefits and the economic criteria of projects or about the rehabilitation of displaced persons from reservoir sites which must be running into millions of acres.

But the main thesis of the book is that the Soviet projects are primarily motivated by the concept of the "unified deep-water transportation system" than by the objectives of flood-control, irrigation and

power as is the case with us in India. Originally, of course, in the twenties electrification was a key theme but later the more strategic concept of linking up all seas and all rivers throughout the Soviet Union so as to enable large ships to move about freely seems to have gripped the imagination of the Soviet leaders. Whether this should have priority over irrigation and power is a very crucial question especially in a country like Russia. In our country, although we would like to give more stress on inland navigation (not deep-water, of course) than is being given at present, we shudder to think of laying stress on this transportational aspect neglecting the others.

The vast projects under execution in Russia require human labour on an equally vast scale for generations to come. It has been the case in the past. The authors quote Soviet sources to indicate that large numbers of workers had to work under very harsh conditions before these great achievements were possible. Whether conditions there are on the whole better or worse compared to our country is not clearly known. Our leading engineers had been to that country but it appears they have not given particular attention to this aspect of the matter.

Another important point that arises from the study of the book is that projects are selected by the Party first and then these are gone into in detail for purposes of execution. If in the matter of selection strategic considerations dominate it is possible that even technically or economically inappropriate projects receive priority over others. The authors have indicated that in several cases this has been the case.

Although the book does not satisfy one's curiosity in full it makes very interesting study indeed.

Our Contributors

P. G. Franke is Visiting Professor at the Engineering College Poona, as an UNESCO Expert. Contributed many thought-provoking articles in foreign technical publications.

S. A. Quader is Additional Chief Engineer, Electricity, Andhra Prodesh, in charge of Generation. Chief Electrical Engineer in the former Hyderabad State. Takes keen interest in our journal from its very inception.

C. S. Parthasarathy is Asst. Chief of the Natural Resources Division, Planning Commission, Govt. of India and has been a frequent contributor to our journal. His recent visit to the States has enabled him to study closely some of the practices and policies with regard to River Valley Projects.

D. Mookerjea is Deputy Chief Engineer of the Damodar Valley Corporation and has already made a mark both as a serious student of hydraulics and design as well as in the field of execution of projects. He was in charge of the construction of the Durgapur Barrage of the D.V.C.

Power Resources Development in Yugoslavia

Yugoslavia's largest power capacity lies in her water power. It has been established that the total power resources, which might be exploited both economically and technically, amount to about 66 billion kWh per year, with the power of over 16,500 MW. It appears therefrom that, according to her water resources, Yugoslavia is one of the relatively richest countries in Europe.

Hydro-power capacities of rivers in Yugoslavia :

River basin	*Surface of river basin in square km*	*Installed power MW*	*Yearly production kWh.* 10^9
Black Sea river basin	177,603	10,381	43.20
Adriatic Sea river basin	55,280	4,907	19.25
Aegean river basin	23,965	1,220	4.13
Total	256,850	16,508	66.58

In view of the fact that the majority of rivers in Yugoslavia, in particular rivers of the Adriatice Sea river basin, dispose in wintertime with large quantities of water and a high water level, there exists the possibility to export power from Yugo lavia to neighbouring countries which have rivers with glacier characteristics and low water level during winter.

A large number of hydro-power plants, put into operation since the war, as well as a considerable number of planned projects, clearly show Yugoslavia's orientation towards the utilization of water power as her main energetic basis.

Coal

The demands for coal grew along with the general economic development of the country. Considering this fact, there were initiated extensive geological and mining research works which showed that there were rich coal deposits in Yugoslavia.

Geological and industrial reserves established so far according to coal quantities:

Coal	*Geological reserves in mill. tons*	*Percentage*	*Industrial reserves in mill. tons*	*Percentage*	*Low calory value*
Pit coal	200	0.75	200	0.9	4500-7000
Brown coal	2570	9.23	1900	8.9	3500-5000
Lignite	25100	90.02	19200	90.2	2000-3500
Total	27880	100.00	21300	100.0	—

In less than ten years the total coal production has doubled.

In order to satisfy the evergrowing coal demands, the production of which amounted to about 15.2 million of tons in 1955, efforts were also made besides the rationalization towards broadening the existing capacities and opening the new ones with rational digging methods and more modern mechanization.

Crude Oil

After the war, extensive works on the research of crude oil have been carried through in Yugoslavia. Along with these research works the e xploitation of crude oil and its processing in refineries have been also undertaken.

Geological and industrial reserves of crude oil established so far :

	A	*B*	*C*	*Total*	*Medium coefficient of utilization*
Geological	18,000	10,000	280,000	300,000	
Industrial	5,400	2,100	56,000	60,000	20.6%

Taking into consideration the oil fields not yet researched, it could be anticipated with certainty that

these industrial reserves will be bigger and that the crude oil production with regard to the existing possibilities and demands will rapidly increase.

The qualities of the crude oil from the four main oil fields, situated mainly in Croatia and Slovenia, are different, but they show a good octant number of benzine and a sensibility to lead, as well as small quantities of sulphur. Therefore, this crude oil is convenient for the production of qualitative liquid fuels which can be partially used also without refining. Domestic production is already covering one third of Yugoslav needs.

Naphta Derivates

Parallel with the production of crude oil, investments were made for the reconstruction and expanding of the existing refineries for the production of naptha derivates. Upon the completion of these works, the capacities of all refineries can be estimated at 900,000 tons annually.

Postitive research works carried out so far on methane have shown that methane might also represent an important energetic basis in the future, though its present use is still insignificant.

The following table indicates the geological and industrial reserves in million cubic meters, established on the basis of the recent researches.

Reserves	*A*	*B*	*C*	*Totally in mill. cubic m.*
Industrial	2,035	700	15,000	17,735
Geological	2,700	900	19,000	22,400

The last results of geological research in North Serbia (Voivodina) indicate that an increase of these reserves might be expected.

There are also in Yugoslavia considerable quantities of bitumen slates which, however, are not yet being completely researched and the possibilities of their exploitation have not yet been checked.

Wood as Fuel

The use of wood as fuel, consumed in considerable quantities particularly in households, considerably diminishes with the development of coal industry and the electrification of the country. Yugoslavia disposes of rather considerable reserves of wood, estimated according to the most recent calculations at 750 million cubic meters with an annual increase of about 23 million cubic meters.

Atomic Energy

Yugoslavia has not remained outside from revolutionary processes in science as regards the freeing of the atomic energy, and she has prepared conditions for the development of nuclear energy. Three Institutes were established, in Beograd, Zagreb and Ljubljana, as well as special organizations for the geological and technical research of radio-active ores.

It has been established that Yugoslavia possesses radio-active, prevailingly uranium ores. These reserves already represent sufficient quantities to cover the Yugoslav needs in the future. Besides, there has been discovered the technology of obtaining uranium from domestic raw materials both in laboratories and through a semi-industrial method in installations constructed in Yugoslavia.

Among other projects, there is also being constructed a reactor and a cyclotron which will serve for the training of the staff and for the production of isotopes.

With regard to the established power resources of the country, briefly drafted here, it is comprehensive that the programme of the economic development of the country mostly takes into account the water power as the main energy basis in Yugoslavia. However, this natural riches of Yugoslavia has not been completely exploited, as it can be seen from the fact that the development of electro-industry was behind its possibilites and needs.

The post-war electrification plan was primarily based upon the erection of powerful hydro-electric plants rendering possible sufficient quantities of cheap electric power. This plan was fulfilled only with great efforts due to a worsening of the international situation. It was carried through mostly by our own forces. The greatest success was achieved in the construction of hydro-electric plants, equipped for the greatest part with the installations of domestic production. Yugoslavia has today her own planning organizations, institutes and factories producing the installations and equipment of electric plants.

The generation of electric power amounted in 1939, resp. 1946, to 1 billion 150 million kWh. From this amount 478 million were generated in hydro-electric plants, and 672 million kWh in thermal power plants. The annual generation amounted to about 70 kWh per head.

The total generation of electric power in 1956 amounted to 5 billion 47 million kWh. From that amount the hydro-electric plants have produced 2 billion 869 million kWh, and the thermal power plants have produced billion 178 million kWh. The annual production per head amounted to 247 kWh.

Parallel with the electric plants, there will be stabilished also high tension lines. Before the war there were in Yugoslavia, except in Slovenia, and to some extent in Istria, no high tension lines of 110 kV, so that the electric plants were operating isolated with low-tension lines, which supplied only narrower, local areas. Today the whole of Yugoslavia is covered by a single system of high-tension lines and transformer stations having a tension of 110 kV, except Macedonia, with her 35 kV high-tension line. It is estimated that there are in all nearly 3,400 km of 110 kV high-tension lines.

Today the electrical energy is already exported from Yugoslavia into Austria under the provisions of the Drava Agreement concluded between the two countries.

Concerning the consumption of electrical energy in the country itself, it is significant that its greatest consumer is industry and mining. Three fifths of the total production are being consumed by these two economic branches. Likewise, there has been noticed a great increase of commercial utilization, brought about by the considerably lowered rates of electrical energy after the war.

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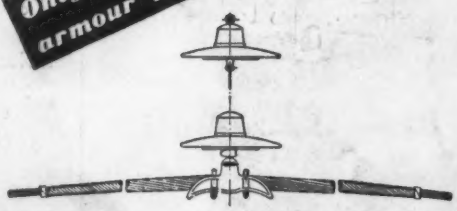

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